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Preventive Oral Health in Underserved Populations: An Economic Analysis

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Preventive Oral Health in Underserved Populations: An Economic Analysis

by

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Dedication

To my parents and my family for their encouragement, patience, support, and prayers.

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Preventive Oral Health in Underserved Populations: An Economic Analysis

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Anjum Khurshid, PhD

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Abstract: Our study adds to the understanding of dental caries prevention in underserved populations. Dental caries is the most common disease of childhood but can be easily prevented. It is therefore essential that policy makers use evidence to promote policies that will help reduce the burden of caries in high-risk children. We collected socioeconomic and demographic data through written surveys from parents of children at the Lyford Consolidated Independent School District in Willacy County. We got a 60% response to our survey. The survey data was matched with dental examination data from a teledentistry project. Only 19% of children in our matched sample had any sealant but 43% had at least one dental caries. Of those without sealants, almost half (49%) had caries while of those with sealants only 19% had any caries. We also found that while half (48%) of those from low-income households (ie, annual income <$25,000) had caries, only a third (34%) of those in high-income households had any caries.

Our data analysis involved econometric modeling to study the impact of various factors including dental sealants on the occurrence of dental caries. We assumed dental

sealant application to be a proxy for past preventive dental care. We used multivariate probit regression to test for endogeneity in our model. The estimation results from univariate probit models showed a strong and robust preventive effect of dental sealants on dental caries. We used Ordinary Least Squares (OLS), logit, probit, and logistic regressions to confirm the results and obtained similar findings. We used our fitted model to simulate the effect of providing sealants to all children in our sample and found that there will be a 52% - 68% decrease in the mean predicted probability of caries in different scenarios. Finally, we used cost estimates from published studies and the annual survey of dental fee by the American Dental Association to calculate cost-benefit of providing sealants through school-based programs. We found school-based sealant programs to be cost-beneficial. Our analysis leads to a recommendation to promote school-based sealant programs in underserved populations.

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Chapter 1: Introduction

When the 12-year-old Deamonte Driver's death was reported in all leading newspapers of the United States in early 2007, a sense of shock and incredulity was expressed by the public.[1] How could the avoidance of a routine $80 tooth extraction lead to the death of a young boy in the vicinity of the nation's capitol? The death was the result of brain infection caused by an untreated tooth. Two operations, six weeks of hospital care and more than $250,000 in medical expenditure could not save the life of this otherwise healthy and bright child (Otto 2007). This led a newspaper to ask this simple question "How can the U.S. spend 40% more per capita on healthcare than any other advanced industrial country in the world and still have worse outcomes than most?" (Goozner 2007)

The United States' healthcare system has been dealing with two somewhat conflicting problems: rapidly increasing expenditure on the one hand and the inability to provide access to quality healthcare for a large proportion of its population on the other. These problems have created many cases like the ones mentioned above, where an easily prevented health problem has morphed into a life-threatening, and at times life-taking, medical condition. Health care spending in the United States increased over 7% in 2005, following double-digit increases in the early part of this century (Ginsburg 2006). The estimated national health care spending reached $2 trillion or $6,697 per person last year (Catlin 2007). Yet, in 2004, about 17% of the U.S. civilian non-institutionalized population or 48 million people were uninsured. More worrisome is the fact that the proportion of uninsured is much higher in children and young people – 35% of 19- to 24-year-olds and 30% of under 18-year-olds, and also in minorities – about 36% Hispanics

[1] The incident got such attention that a *Childrens' Dental Health Improvement Act of 2007* (also called Deamonte's Law) was introduced in the U.S. Congress in May 2007 to improve access to dental care for the poor and prevent such unnecessary deaths. (http://www.house.gov/cummings/press/07mar29b.htm)

or Latinos are uninsured (Rhoades 2005). The number of Americans without dental insurance is twice this number – about 108 million in 2000 (US DHHS 2000). The United States spends over $78 billion on dental care, of which most is out-of-pocket expenditure (Brown 2001). It is therefore necessary that dental public health be included in the national debate on health care policy in the United States (JADA 2006).

The mouth is often referred to as a window into the health of a body (JADA 2006). Oral disease causes significant pain and suffering besides the loss of productivity in workplace (GAO 2002). In addition, many systemic diseases may be first noticed by lesions in the mouth. Oral health problems may also be linked to systemic illnesses related to immunological or nutritional deficiencies (Slavkin 2000). Oral cancer is one of the most aggressive carcinomas in the body. Dental caries is the most common chronic disease of childhood in America and Canada (US DHHS 2000, Halstrom 2006). About 80% of the 17-year-olds in America have had a caries experience in their lifetime. And 25% of the population has about 80% of dental caries (US DHHS 2000). In 2004, Americans made about 500 million visits to dentists (CDC 2005). All these facts point to the importance of oral health in the overall well-being of the society.

In the public policy arena, oral health concerns have not been at the top of the healthcare agenda. Yet, from time to time a policy debate on oral health has occurred. The Surgeon General's report on oral health in 2000 was widely discussed and its description of oral diseases as a "silent epidemic" has been used in many descriptions of dental health policy (Levy 2006). In Healthy People 2010, decrease in dental caries was one of the primary objectives set for the nation under oral health (Objectives 21-1, 21-2, 21-3). It also set a 50% target for the proportion of children who have received dental sealants on their molar teeth (Health People 2010 Objective 21-8) (USDHHS 2000). In 2003, the Surgeon General released a National Call to Action to Promote Oral Health in an effort to keep oral health on the healthcare agenda of the nation (US DHHS 2003).

Concerns about oral health have also been the topic of discussion in several medical and public health journals (Halstrom 2007, JADA 2006; Selwitz 2007).

Fortunately, dental caries can be rather easily prevented with regular dental care. Preventive strategies for dental caries include water fluoridation, fluoride varnishes, fluoride toothpastes, dental sealants, healthy diet, and regular cleaning of the teeth. While all these strategies should be adopted as part of healthy behavior, from a policy perspective we study the most important strategy to fight dental caries in children – dental sealants. 90% of dental caries occur on the pit and fissure surfaces of teeth but can be very easily prevented if dental sealants are applied to these surfaces (Weintraub 1987; Ripa 1985). Less than a third of children in the United States today have sealants on their teeth (CDC 2005). From a policy perspective it is therefore very useful to study the impact of dental sealants in children with highest risk of getting dental caries. These include children from minorities and those in underserved areas (Flores 2002; Ismail 2003; Casamassimo 2003; Warren 1990).

Our study asks two questions related to dental caries in children. The first question is to find the effectiveness of dental sealants in preventing dental caries in Hispanic children living in underserved areas. In the presence of several studies on dental sealant effectiveness, the reason we ask this question is to address the lack of published literature on dental caries in Hispanic children in underserved areas, particularly in Texas. The second question is related to the first question because it is relevant only if we find dental sealants to be an effective strategy in reducing dental caries in the underserved population of our study. If dental sealants are found to be effective in reducing caries then the policy-relevant question that follows is whether it is cost-beneficial to provide dental sealants to children in these populations. We choose an underserved population in south Texas and collect data to answer these two questions.

Chapter 2 discusses the theory of dental caries prevention. We give a brief overview of the etiology, microbiology, and pathology of dental caries. Then we present the existing scientific evidence on the effectiveness of dental sealants in reducing dental caries. We rely only on published and peer-reviewed information. Evidence-based medicine and evidence-based public policy rely on systematic reviews of literature to describe the quality of evidence for different interventions. We use systematic reviews of dental sealants and other published works to give an overview of existing evidence related to dental caries and dental sealants.

Chapter 3 describes the magnitude of the problem of dental caries in the United States in general, and in minority and underserved populations, in particular. We discuss the disparity in oral health that is shown by several nationally representative health surveys like National Health and Nutrition Examination Survey (NHANES) and the National Longitudinal Survey of Adolescent Health (Add Health). We also present studies that have looked at the impact of different socioeconomic and demographic factors to explain the disparities in burden of dental disease.

Chapter 4 explains the methodology we adopt in our research. We describe some of the characteristics of our study population, the development of survey instrument, pilot testing of the survey, and distribution and collection of the written surveys. We also briefly describe the teledentistry project from which we obtained the clinical dental data. A copy of the actual survey used (in English and Spanish) is attached and the variables in our data are listed.

Chapter 5 describes the data analysis regarding sealant effectiveness. We detail our model specification, basic statistics of our data, and results from modeling. We report results from ordinary least squares, logit, probit, and logistic regression models. We also report results from multivariate probit models to test for endogeneity of key policy variables in the model. The chapter ends with a discussion of the estimation results in the light of existing literature on sealant effectiveness and dental caries.

In Chapter 6, we study another aspect of dental care in underserved populations, that of dental utilization. Children from minorities, low income households, and rural areas have been found to have low dental utilization (Kenney 2005; Manski 2001; Lewis 2007; Fisher 2004; Vargas 2002). Since most children in our study population fall under all of these situations, we study the factors in our data that may affect their dental utilization. We present the model specification, describe simple statistics, and use econometric methods to estimate the factors that explain dental utilization in our data.

The penultimate chapter (Chapter 7) uses the fitted models from Chapter 5 to predict dental caries in our study population under different scenarios. The simulation helps us discuss the potential impact of different policy options related to dental sealants in our population. We use these simulation results to allocate dollar values to the cost of providing sealants through school-based programs and the potential savings of preventing dental caries through such preventive regimes. The results of the cost-benefit analysis are also presented.

The final chapter concludes by summarizing some of the key findings of our research. It also presents the limitations of our analysis and data. Finally, future directions for further research are discussed.

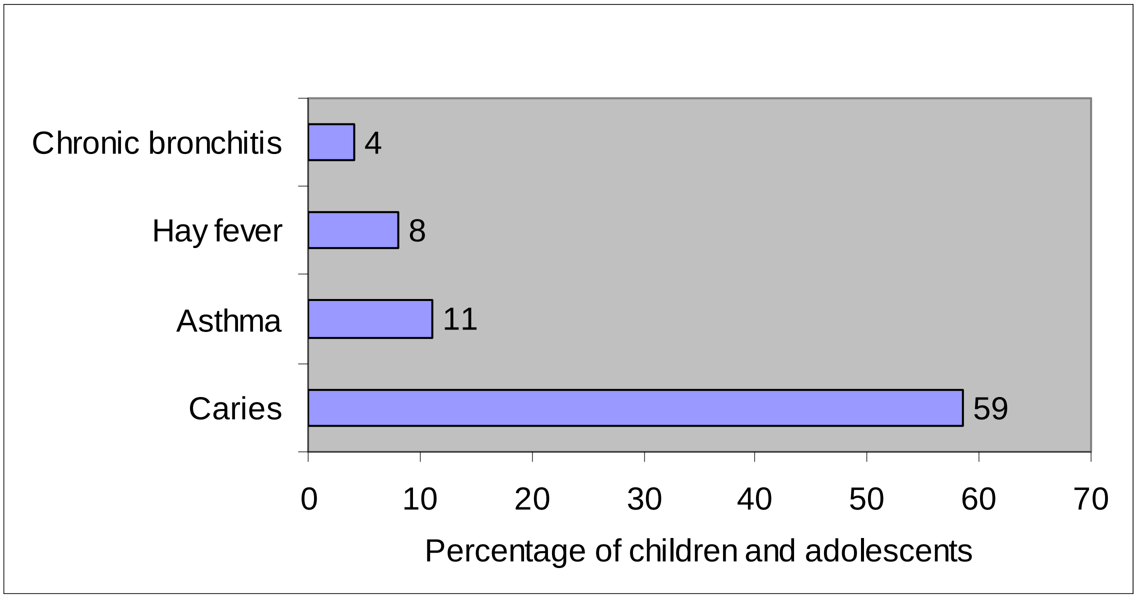
Chapter 2: Theory of Dental Caries Prevention

2.1 BACKGROUND

From a policy perspective, oral health has a significant impact on the economy of the United States. Not only does oral health expenditure form a substantial component of total health expenditures in the United States, oral disease causes significant loss of productivity in the workplace (GAO 2002). Over $78 billion are spent on dental expenditures annually in the United States. An estimated 4 - 5 million children and adolescents' activities are severely affected or interfered with due to tooth decay (US DHHS 2000). The first-ever Surgeon General's Report on Oral Health described a "silent epidemic" of dental and oral diseases in America (USDHHS 2000).

Dental caries is the most common chronic disease of childhood in America, being five times more common than asthma, the second most common disease (Figure 2.1). Yet, more children are unable to get dental care than any other health service (Waldman 1998). More than other chronic diseases, dental caries is quite easily prevented with regular preventive and screening services and adoption of healthy dental behaviors (Axelsson 1999). 50% of children between 5 and 9 years have untreated tooth decay. 78% of children have dental caries by the time they are 17 (Eldestein 1995). And 80% of tooth decay is concentrated in 25% of children (USDHHS 2000).

FIGURE 2.1: Dental caries in 5- to 17-year-olds in the United States



More statistics and data can be quoted to show the extent and severity of the problem of dental caries in the United States. The cost of such a disease to the quality of life of individuals, to the productivity of the economy, and to the overall health of the population has also been well documented (GAO 2000, de Oliveira 2006; Oscarson 2007; Quandt 2007; Selwitz 2007). However, public policy in this area is still relying on rather outdated models of chronic disease management. Similar public policy challenges exist in dealing with many other epidemics in the United States, such as obesity, sexually transmitted infections, and diabetes. Unfortunately, quite consistently, minorities and low income groups living in underserved areas bear the greatest burden facing these challenges (Flores 2002; Warren 1990).

For a long time, health policy regarding diseases has been based on the principles of clinical practice. The key assumption of such policies was that what is good for a patient should be good for the population. However, the rapidly evolving field of public health is replete with evidence showing that population-level remedies for chronic and widespread disease may look somewhat different than the advice given to a patient in a clinic. This paradigm shift of making health policy based on a prevention or wellness model rather than the traditional disease-management model has already been adopted in many countries around the world (Kuh 2004) This is particularly true in the fight against dental caries at a population level because it is an easily preventable infection. Countries like Sweden have minimized dental caries in their young population through sound, preventive care including regular screening (Axelsson 1993).

Our study looks at the role of one particular preventive service, dental sealants, in decreasing the prevalence of dental caries in an underserved population of school children. We intend to show findings that will help in informing policy makers about the burden of disease in the Hispanic population in such underserved areas. We also intend to show the impact of providing preventive services on reducing dental caries in this population. We will study additional factors that may influence the effectiveness of sealants in dental caries prevention as well.

We begin by describing a theoretical model of dental disease prevention developed by Anderson (1997) and widely used in the field of oral health. This will be followed by a short explanation of dental disease, its etiology, pathology, and prognosis. We will then look at published literature related to dental caries and sealants.

2.2 DENTAL PUBLIC HEALTH

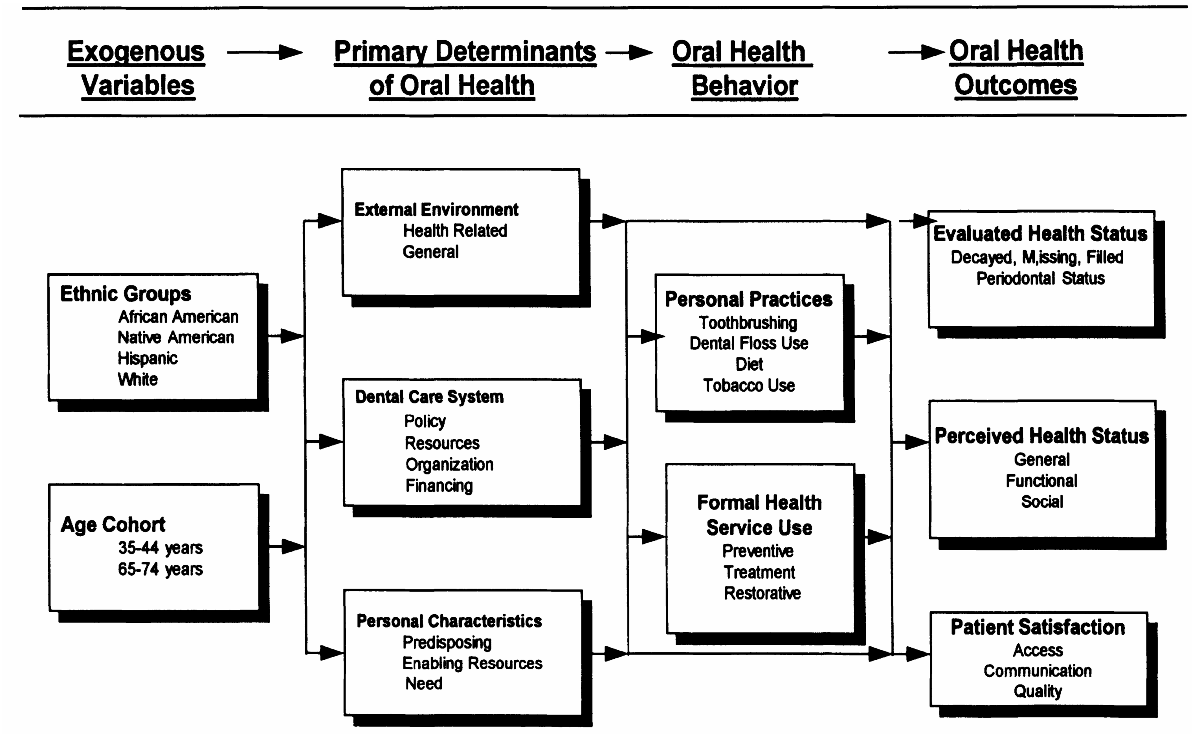
The World Health Organization defines health as a "state of complete physical, mental, and social well-being and is not merely the absence of disease or infirmity" (World Health Organization 1946). This definition has been widely used because of its broad vision of health and because it can be applied both to an individual and the society. The Institute of Medicine explains the role of public health from a societal perspective as well and defines it as "fulfilling society's interest in assuring conditions in which people can be healthy" (Institute of Medicine 1988). These aspects of health and public health are combined with dental care by the American Dental Association to arrive at the definition of dental public health. The definition adopted by the American Board of Dental Public Health is

> The science and art of preventing and controlling dental diseases and promoting dental health through organized community efforts. It is that form of dental practice that serves the community as a patient rather than the individual. It is concerned with dental health education of the public with applied dental research and with the administration of group dental care programs, as well as the prevention and control of dental diseases on a community basis (American Association of Public Health Dentistry 1998).

2.3 ANDERSON'S THEORETICAL MODEL

We study dental caries from a public policy perspective and hence use principles of dental public health as a framework to discuss preventive strategies for dental health promotion (Dunning 1986). A popular and well recognized policy-relevant theoretical model of dental care interventions is one developed by Andersen (1997). The model, known as Andersen's Behavioral Model of Health Services Utilization (Andersen, 1968, 1995), is based on a systems approach (Easton 1965) where outcomes are determined by inputs and other environmental factors. It describes a process. The inputs or external environment affects intermediary variables to result in desired health outcomes (Figure 2.2).

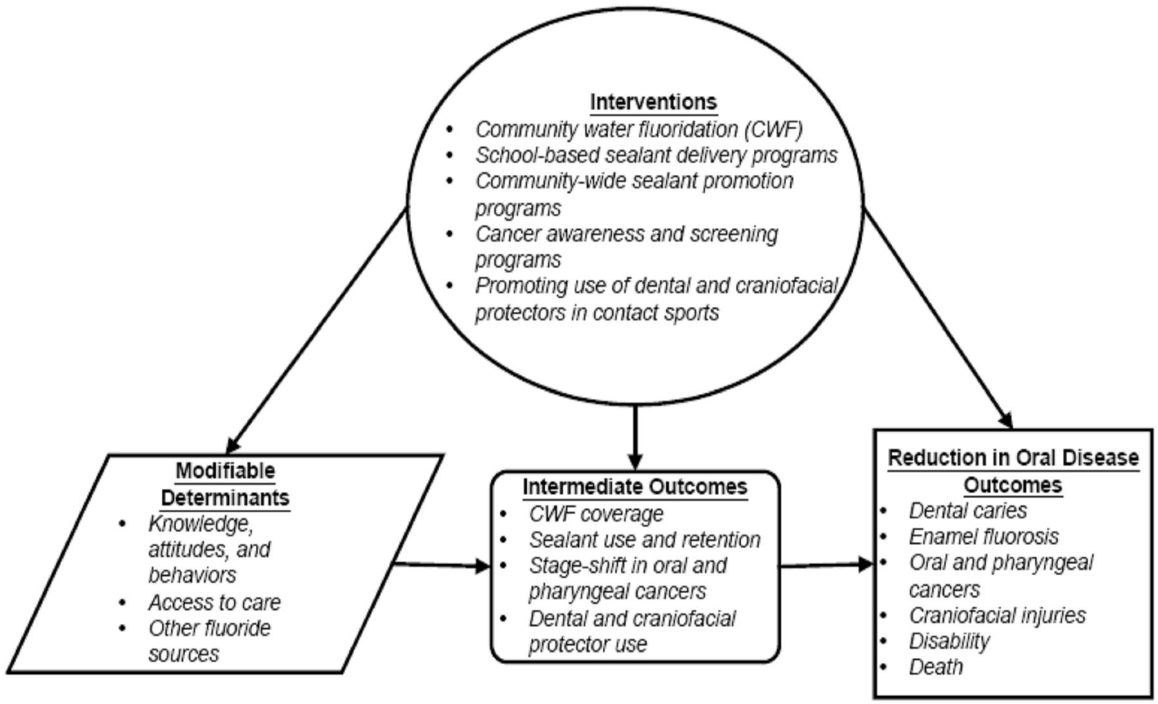
FIGURE 2.2: Andersen's conceptual framework used by ICS II



Source: Andersen 1997

For dental health, the external environment consists of the dental care delivery system, fluoridated water and characteristics of the population. The intermediate variables include health behaviors such as dental hygiene and dental care utilization. These in turn affect the dental health outcomes which are measured in terms of dental health, incidence of disease, and satisfaction with dental services. Some intermediary outcomes may be measured to evaluate effectiveness of interventions, such as sealant use and retention or communities with fluoridation systems in place. However, the eventual outcomes relate to decrease in dental caries, oral cancers, and morbidity. This theoretical framework has been found to be effective in policy analysis to "describe, predict, and explain population-based health behaviors and health outcomes" (Andersen 1997). Andersen's approach was used by the US Task Force on Oral Preventive Services (2002) and is also endorsed by the Association of State Dental Directors. The same has also been used in the World Health Organization's (WHO) International Collaborative Study of Oral Health Outcomes (ICS-II) – a multi-site international study on dental health. Figure 3 shows the application of Andersen's model to look at factors affecting dental health.

FIGURE 2.3: Logic framework showing interventions, modifiable determinants, intermediate and oral disease outcomes



Source: Truman 2002

The exogenous factors that affect dental care include community- and population-level characteristics. Water fluoridation, community norms, policies on tobacco use and community health promotion are some of these factors that affect oral health. Dental care delivery system, which includes the mechanism to provide dental services in the community, also affects the accessibility and utilization in different populations (Kenney 2005). The delivery system includes organizations, policies, resources and financial arrangements that influence availability and access to dental care.

According to Andersen's conceptual model, personal characteristics of the population also affect dental care at the individual's level. Sociodemographics, acculturation, language, length of time in the community, and education are some of the factors that are included under personal characteristics. Tooth brushing, flossing, diet, and tobacco use are some of the oral health behaviors at the personal level that also influence the oral health outcomes.

The systems approach is completed by adding a feedback loop where dental health outcomes affect the environment. At the same time these outcomes also influence the decisions regarding inputs into the delivery system. A feedback that shows inadequate dental care leads to policy change in dental health policies.

2.3.1 Andersen's Model and Economic Theory

Swank et al (1986) have argued in detail how Andersen's model is appropriate to study preventive dental services. They use NHANES-I data from 1971-75, to study various factors that affect dental preventive behavior. The effect of these factors, such as age, education, race, and income were determined by combining Andersen's model with economic theory. The principle applied to understand individual preventive behavior was that "individuals combine medical care services and their own time and effort to produce health and other commodities in an effort to maximize overall personal utility or satisfaction" (Swank 1986, p.177). These concepts derive their roots from the early discussions on the economics of health care and why people seek health (Arrow 1965). Welfare economics seeks to explain these behaviors using the utility approach (Hurley 2001). Hurley lists four major tenets of neo-classical economics: utility maximization, individual sovereignty, consequentialism, and welfarism[2] and discusses how these

[2] *Utility maximization* is a behavioral assumption that individuals choose rationally but without consistency one could learn little from such behavior. *Individual sovereignty* recognizes the individual as the best judge of his/her welfare. *Consequentialism* means that policy must be evaluated in terms of its result or effect not its process. *Welfarism* means that the basis of decisions should be the utility levels achieved by individuals.

assumptions affect health behaviors of individuals. Many health economists believe that important assumptions of welfare economics theory may not always hold in health care (Rice 1998). For example the assumption of individual sovereignty, that describes the individual as the best judge of taking the decision to seek health care, is violated in health sector because of information asymmetries between the providers (doctors) and consumers (patients). Also, health is often essential for a person's existence; its value or benefit cannot be just linked to economic resources of an individual. Others have argued that health and not utility is the most relevant outcome for conducting normative analysis in health sector (Feldstein 1963). So as early as 1963, Feldstein asked "… should not health care be allocated to maximize the level of health of the nation instead of the satisfaction which consumers derive as they use health services?"

From this theoretical debate, it is evident that understanding preventive health behaviors including those related to dental health, involve application of economic principles. However the application of economic principles must be done with additional input from social, political, and cultural studies.

2.4 DENTAL HEALTH POLICY

One of the most significant studies that produced evidence in support of a prevention-oriented dental health policy was the World Health Organization's first International Collaborative Study of Dental Manpower Systems in Relation to Oral Health Status (ICS-I) that was conducted between 1973 and 1981 (Cohen 1987). Dental systems in ten different countries were studied through surveys in three different age groups. The findings of this elaborate study suggested that oral health beliefs of the population, personal health practices, and the commitment to prevention, were as important to the oral health of the population as availability of manpower and access to dental care (Cohen 1987). Based on these findings a second survey and examination, ICS-II, was conducted in three locations in the United States (including San Antonio, TX) and four international sites (Germany, Japan, New Zealand, Poland – later joined by France). The ICS-II also used the above mentioned Andersen's Behavioral Model of Health Services Utilization (Anderson, 1968, 1995) as its conceptual framework. The framework was considered adequate to understand the differences in health outcomes in diverse populations.

Results of the ICS-II surveys, conducted by the WHO, allowed international comparison for a disease that affects people all over the world throughout their lifetime. The nature of the disease however does not differ from one country to another. The principles of prevention apply to all dental conditions. Axelsson (1999) summarizes the new findings based on ICS-I and II as follows:

1. dental workforce and dental utilization alone are not a good measure of the oral health status of a population
2. school-based preventive treatment for childhood oral disease is very effective
3. promotion of preventive services by the government and dental professionals is an effective factor for ensuring oral health

Preventive services were therefore clearly shown as the most effective strategy to reduce the incidence and morbidity of dental caries.

2.4.1 Preventive Dental Care

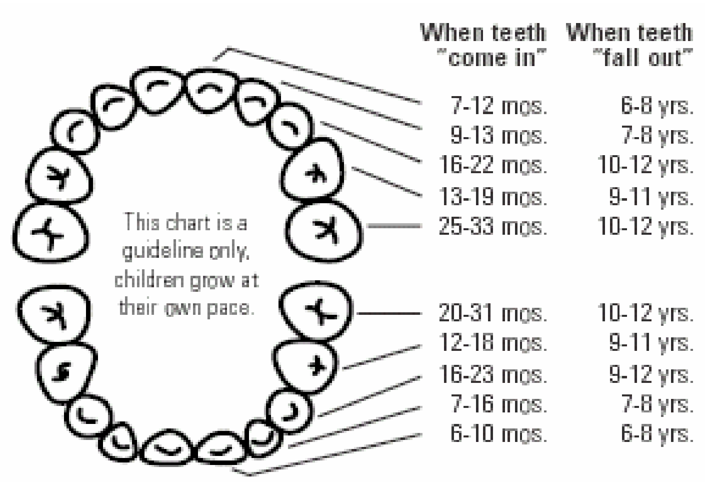
In the field of public health, prevention is classified as primary, secondary, or tertiary (Last 1998). The damage caused by a preventable disease increases depending upon the stage at which preventive care is provided. The damage is most likely to be higher when tertiary prevention is the main public health strategy to fight a disease. Such damage is minimized through primary prevention which takes place before the disease occurs. It is therefore cost effective, if possible, to adopt a primary prevention public health strategy for all chronic diseases. On the same principle, dental care can also be classified as primary, secondary, and tertiary prevention. Axelsson (1999) has added another category of primary primary prevention, which includes all measures to prevent postnatal transmission of bacteria causing dental caries and poor dietary habits from mother to child.

Primary prevention for dental caries, gingivitis and periodontitis would include a healthy dentition, brushing and flossing, fluoridated water, dental sealants, and regular screening for any oral disease. Secondary prevention would occur after the disease has occurred and it will focus on preventing recurrence of dental caries, gingivitis, and periodontitis following some treatment. Finally, tertiary prevention takes place after the damage has been done and includes restoration, scaling and periodontal surgery to treat the after effects of dental disease.

2.5 WHAT IS DENTAL CARIES?

Dental caries remains the major dental health problem among school children in the United States. Childhood and early adolescence are periods of immense importance in the development of healthy dentition. The first primary tooth usually erupts around the age of 7 to 12 months (Figure 2.4). Between the ages of 6 to 8 years, children have a majority of their primary teeth, while their permanent first molars and incisors are erupting in their mouths. By the age 11 or 12, most of the primary teeth are lost as permanent teeth are erupting. By the age of 15 years, all permanent teeth have erupted except for third molars. The extent of dental caries in school-age children can be estimated by the fact that by age 15, approximately 75 percent of adolescents have experienced dental decay. About 85% of adults aged 18 and older are affected by dental caries at some time in their lives (USDHHS 2000).

FIGURE 2.4: Primary teeth and dental milestones in children

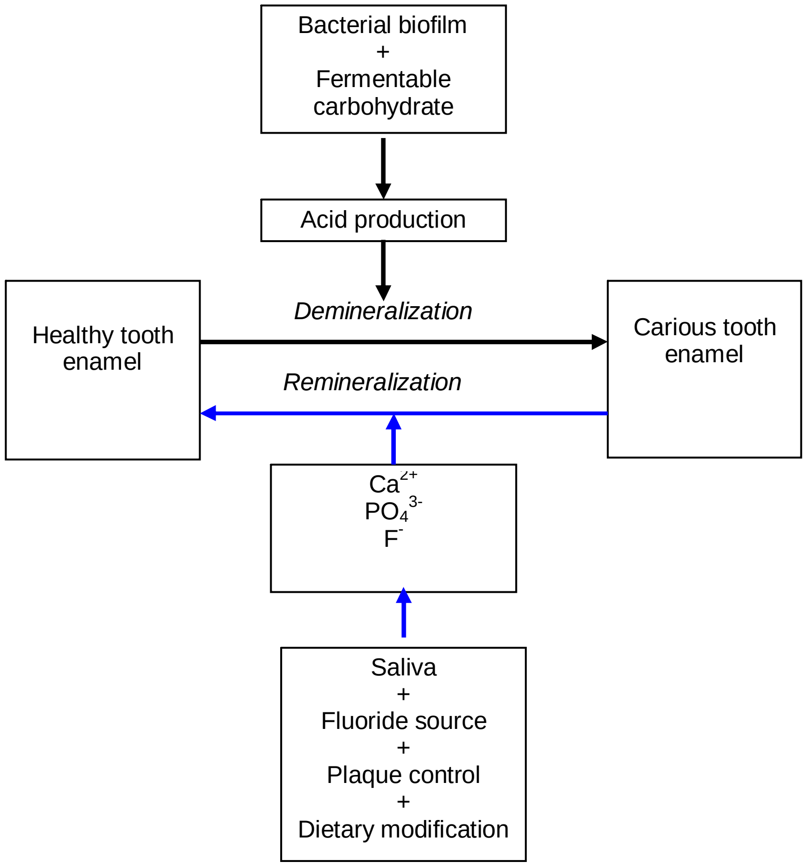


Source: http://www.health.gov.on.ca/english/public/pub/early/teething.html

2.5.1 Etiology and Pathology of Dental Caries

Dental caries is defined as "the presence of 1 or more decayed (noncavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces" in any tooth (adapted from AAPD definition of early childhood caries 2003). There are over 350 species of bacteria that regularly reside in the oral cavity, but only a few have the ability to colonize a tooth surface. Bacteria are found in the oral cavity where they may multiply to form a gelatinous layer or biofilm on tooth surfaces called dental plaque. A plaque that causes dental caries usually may contain about half a billion bacteria on a single tooth. It is estimated that $1mm^3$ of dental plaque, weighing about 1 mg, contains more than 200 million bacteria (Scheie 1994). These bacteria, of which *Streptococcus mutans* is the most important, are able to ferment sugars and other carbohydrates to form lactic acid and other acids. The acid results in microscopic damage to the minerals in the tooth enamel (outer hard covering of the tooth). The process of cavity formation as a result of bacterial action is described in Figure 2.5:

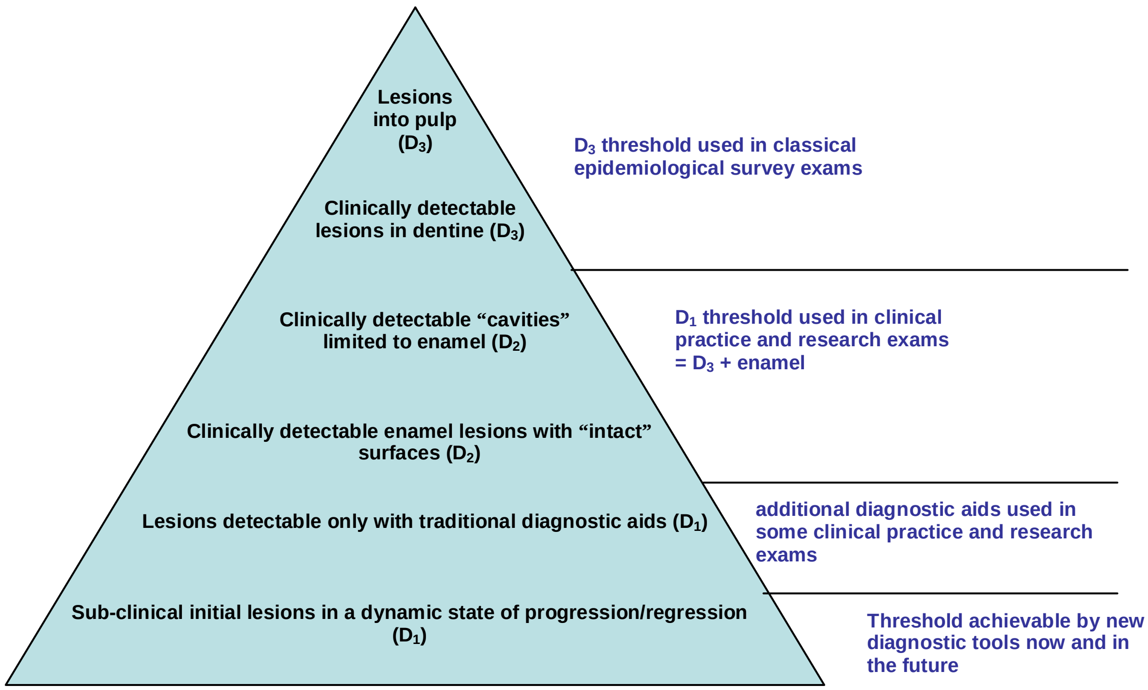
FIGURE 2.5: Process of change in tooth enamel



Source: Selwitz 2007

The caries infection in enamel if unchecked can lead to dissolution of the tooth structure to the extent that a cavity is formed. The cavity may progress to go through the dentin (part of the tooth located under the enamel) where it can affect the nerves and blood vessels directly. This may lead to severe toothache and increased sensitivity to hot and cold drinks and food. The same process can also take place in the root of a tooth affecting the cementum (outer covering of the root) and dentin, in what is sometimes termed as root caries in contrast to crown caries which affects the part of tooth above the gingivia (Selwitz 2007). Figure 2.6 describes the iceberg metaphor for dental caries, emphasizing the fact that tooth decay may remain invisible to an untrained eye in many cases. Studies have also shown the limitations of diagnostic tests for dental caries, such that, a significant number of carious lesions are missed during examinations (Selwitz 2007).

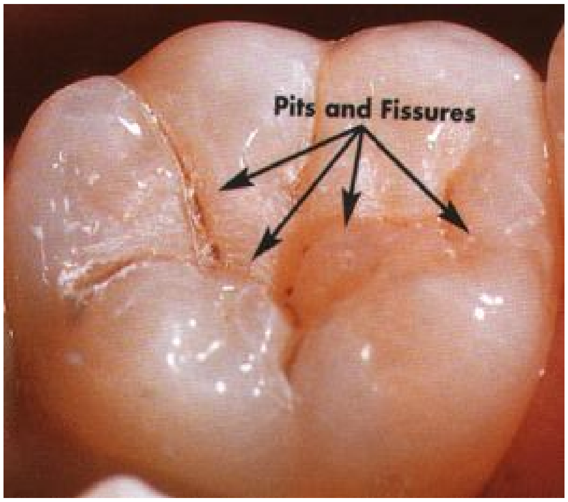
FIGURE 2.6: Iceberg phenomena of dental caries diagnosis



Source: Pitts 2001

While dental caries may occur at any age, early childhood caries affects 6 out of 10 children before the age of 5 (US DHHS 2000). Dental caries also has a high incidence in adolescents (Kaste 1996). Although there has been overall decrease in dental caries in older children and adolescents, different surfaces of teeth show this decrease differently. Smooth surface caries have shown a greater decrease at the population level than caries on the chewing surfaces with pits and fissures. Most adolescent caries now is confined to the pits and fissures (Burt 1998).

FIGURE 2.7: Pits, fissures and dental sealants



Pits and Fissure

Sealant applied to pits and fissures

Source: (http://www.bestofmorganhill.com/Gabor_DDS/ultraseal_xt.htm)

Pits and fissures on the occlusal surfaces of the teeth provide a relatively convenient location for growth of bacterial colonies that cause tooth decay. The deep recesses on the chewing surface of the tooth are called fissures and when two or more fissures join, it becomes a pit (Figure 2.7). These surfaces are hard to clean with regular brushing and fluoride seems less effective in preventing caries on them. Food particles are more likely to be impacted in these recesses and those lodged in deeper pits may not be dislodged even by brushing. Data from 1988-91 National Health and Nutrition Examination Survey (NHANES) showed that over 80% of tooth cavities in school children were pit and fissure cavities (Segal 1997). Other studies show this number to be around 90% (Ripa 1993). The application of sealants on chewing surfaces covers these pits and fissures thus preventing bacterial colonization of the teeth and eventual caries formation.

2.6 LITERATURE REVIEW ON DENTAL CARIES PREVENTION

2.6.1 Evidence-based Dental Caries Prevention

A paradigm shift that occurred in health care some 40 years ago was the result of a movement to promote evidence-based decision making in clinical practice. David Sackett was one of the leading proponents of this shift (Sackett 1996). A major mechanism to decide upon the best evidence for various practices and treatments was proposed by Archie Cochrane in 1972 (Cochrane 1972). Later, the Cochrane Collaboration was established to systematically review evidence related to various health issues.[3] Evidence-based medicine, as this new paradigm was called, is now the standard of practice in the United States and has extended beyond medicine to other areas. For instance, evidence-based public policy making is the equivalent movement within the field of public policy to make policy making process based on evidence of successful programs and policies (Davies 2001).

Sound public policy in dental health also needs to be based on evidence as shown in published and peer-reviewed literature. There are several different categorizations that describe the quality of evidence. For instance, the US Preventive Services Task Force has developed a system of grading the quality of evidence shown in Table 1. Many other systems have been developed by other groups (Atkins 2004).

TABLE 2.1: U.S. Preventive Services Task Force (USPSTF) recommendations and ratings

The USPSTF grades its recommendations according to one of five classifications (A, B, C, D, or I) reflecting the strength of evidence and magnitude of net benefit (benefits minus harms).

A.	The USPSTF strongly recommends that clinicians routinely provide [the service] to eligible patients. *The USPSTF found good evidence that [the service] improves important health outcomes and concludes that benefits substantially outweigh*

[3] See http://www.cochrane.org/

	harms.
B.	The USPSTF recommends that clinicians routinely provide [the service] to eligible patients. *The USPSTF found at least fair evidence that [the service] improves important health outcomes and concludes that benefits outweigh harms.*
C.	The USPSTF makes no recommendation for or against routine provision of [the service]. *The USPSTF found at least fair evidence that [the service] can improve health outcomes but concludes that the balance of benefits and harms is too close to justify a general recommendation.*
D.	The USPSTF recommends against routinely providing [the service] to asymptomatic patients. *The USPSTF found at least fair evidence that [the service] is ineffective or that harms outweigh benefits.*
I.	The USPSTF concludes that the evidence is insufficient to recommend for or against routinely providing [the service]. *Evidence that [the service] is effective is lacking, of poor quality, or conflicting, and the balance of benefits and harms cannot be determined.*

2.6.2 Effective Strategies for Dental Caries Prevention

The following section looks at the evidence regarding effective strategies to decrease dental caries at the population level. Since we study sealant application as a preventive strategy for dental caries in underserved populations (Hispanic children in south Texas), we focus particularly on studies related to sealant programs. Four significant reviews of literature regarding dental caries prevention that have been published since the year 2000 can be used as the major source of looking for evidence regarding sealant programs:

- Report of the Task Force on Community Preventive Services on Interventions to Prevent Dental Caries, Oral and Pharyngeal Cancers, and Sports-related Craniofacial Injuries (Truman 2002)
- NIH Consensus Statement on Diagnosis and Management of Dental Caries, 2001 (NIH 2001)
- Cochrane Collaboration Review on pit-and-fissure sealants for preventing dental decay (Ahovuo-Saloranta 2004)
- Report of the Surgeon General on Oral Health 2000 (US DHHS 2000)

2.6.2.1 US Task Force on Community Preventive Services

The US Task Force on Community Preventive Services was a group of experts that looked at available evidence about effective interventions for decreasing dental disease. Truman et al (2002) describe the results of this systematic review on effectiveness of interventions to prevent dental caries. The Task Force particularly focused on school-based or school-linked pit-and-fissure sealant programs. School-linked programs may be conducted in school settings or in clinic settings outside the school while school-based programs are confined to school premises. The systematic search of articles and reports published between 1966 and December 2000, found 37 studies on effectiveness of sealant programs for reducing dental caries. 27 of these were excluded from the reviews because of insufficient data, limitation in design, or inappropriate effect measure (Truman 2002, p. 29).

The 10 studies included in the analysis are listed in Table 2.2. Only 6 of these were school-based sealant programs (as indicated in the table). Not all of these programs are US-based and none focuses specifically on Hispanic children.

TABLE 2.2: Studies on sealants and dental caries in the systematic review of literature

Authors	**Year (school-based or not)**	**Title**
Bagramian RA	1982 (SB)	A 5-year school-based comprehensive preventive program in Michigan, U.S.A.
Bravo M, Baca P, Llodra JC, Osorio E	1997 (SB)	A 24-month study comparing sealant and fluoride varnish in caries reduction on different permanent first molar surfaces
Burt BA, Berman DS, Silverstone LM	1977	Sealant retention and effects on occlusal caries after 2 years in a public program.
Horowitz HS, Heifetz SB, Poulsen S.	1977(SB)	Retention and effectiveness of a single application of an adhesive sealant in preventing occlusal caries: final

		report after five years of a study in Kalispell, Montana
Klein SP, Bohannan HM, Bell RM,	1985(SB)	The cost and effectiveness of school-based preventive dental care
McCune RJ, Bojanini J, Abodeely RA	1979	Effectiveness of a pit and fissure sealant in the prevention of caries: three-year clinical results
Messer LB, Calache H, Morgan MV	1997	The retention of pit and fissure sealants placed in primary school children by Dental Health Services, Victoria.
Selwitz RH, Nowjack-Raymer R, Driscoll WS	1995(SB)	Evaluation after 4 years of the combined use of fluoride and dental sealants.
Songpaisan Y, Bratthall D, Phantumvanit P	1995(SB)	Effects of glass ionomer cement, resin-based pit and fissure sealant and HF applications on occlusal caries in a developing country field trial
Sterritt GR, Frew RA, Rozier RG	1994	Evaluation of Guamanian dental caries preventive programs after 13 years

In terms of the conclusions of the systematic review, the Community Preventive Task Force found the relative median decrease in dental caries in all these 10 studies to be 60%, ranging from 5% to 93%. Only 4 of the 10 studies took place in the United States (Bagramian 1982, Horowitz 1977, Klein 1985, Selwitz 1995), but mean caries reduction in both US and non-US studies was found to be exactly the same, 60%. The results varied depending on the length of the follow-up. For instance, three studies that measured the decrease over a period of 4 years, found the relative decrease to be 65% (Bravo 1997, Klein 1985, Selwitz 1995). All study populations involved children aged 6-17 years in both primary and permanent teeth. None of these studies in the United States looked at the special case of Hispanic children, as proposed by our study. For the general population, however, the Community Guide results showed strong evidence that school-based sealant programs “are effective in reducing decay in pits and fissures of children’s teeth” (Truman 2002, p.31). School-based programs showed a higher median effect (65%) than school-linked programs (37%).

The Task Force also identified main barriers to the implementation of school-based sealant programs as described in various evaluation studies. General education and knowledge about prevention and oral health was lacking in the public and even some health professionals. Similarly, unavailability of adequate resources with school administrators to run these programs and state dental practice laws limiting authority of dental hygienists to apply sealants without dentist's supervision also hamper introduction of such effective interventions. There are also some concerns in private practice dental practitioners that providing school-based preventive services to children may keep them from their regular dental appointments in the clinic or doctor's office.

2.6.2.2 NIH Consensus Statement on Diagnosis and Management of Dental Caries

The other systematic review we look at as an example is one conducted by the Agency for Health Research and Quality and National Library of Medicine (AHRQ/NLM). This was part of an effort by the National Institutes of Health that held a conference in March 2001 to develop consensus on the diagnosis and management of dental caries. The conference evaluated available scientific information related to dental caries (Glock 2001). A bibliography of available evidence on the subject was compiled by the AHRQ and NLM. The bibliography is available online and has 1,592 unique citations from January 1980 to December 2000. The bibliography primarily includes articles published in English related to dental research. It includes both human and animal subject research. It also includes some foreign language articles as well as selected conference papers.

We study the preventive impact of sealants on dental caries in underserved population of Hispanic students in a school district in the south Texas county of Willacy. We also propose analyzing the economic dimension of such a program. We used search terms related to our study to list relevant research articles in the NLM bibliography. The details of the search are in Appendix 2. A under each search term used. While there were several articles that had the word “sealant” or “sealants”, there was only one that included Hispanic children in its title (Ramos-Gomez 1999). We found none of these citations included Mexicans, Latinos, minority, or minorities in their title. Also, only one included the term underserved (Warren 1990). When we looked specifically for “sealant programs” only 3 citations out of the 1,592 in the list mentioned any type of sealant programs in their title (Ismail 1989, Kumar 1997, Werner 2000).

The NIH Consensus Statement that resulted from the deliberations of experts in the field in the NIH Consensus Conference on Diagnosis and Management of Dental Caries Throughout Life (NIH 2001) found that diagnostic techniques for dental caries, particularly for noncavitating caries, were not rigorously evaluated. The Statement therefore emphasizes the need for primary prevention. Water fluoridation, fluoride gels and varnishes to permanent teeth, dental sealants (pit and fissure) and noncariogenic sweeteners or a combination of these were found to be effective. Early identification and treatment to reverse early stages of dental caries were also found effective. These preventive measures include fluorides in water, fluoride varnishes, chlorhexedine gels, and sealants.

The NIH Consensus Statement also lists the risk factors for dental caries based on the review of evidence. According to the Statement “most consistent predictor of caries in children is past caries experience.” Inadequate exposure to fluoride, presence of restorations or oral appliances (braces), carbohydrate consumption, some medical conditions causing dry mouth (Sjogren’s syndrome), radiation exposure of head and neck, and poor oral hygiene are all factors that have been found to increase the risk of dental caries. Low socioeconomic status was also linked to dental caries although it may be related to other factors such as oral hygiene and access to care. Based on the evidence presented, the panel finally concluded that there appeared a need for “a paradigm shift in the management of dental caries" towards early detection and prevention of such lesions (NIH 2001, p.18).

2.6.2.3 Cochrane Review of Pit and Fissure Sealants

The Cochrane Collaboration conducted a systematic review of evidence related to pit and fissure sealants for preventing dental decay in permanent teeth (Ahovuo-Saloranta 2004). The review also compared different types of sealant materials used[4] (mainly resin-based and glass ionomer cements). Articles published between 1966 and 2002 were reviewed. Randomized and quasi-randomized trials of at least a year's duration were selected. The age group used was children and adolescents under 20 years of age. The results of the meta-analysis showed reduction in caries ranging from 86% within one year to 57% at 4.5 years. It also found retention rates for sealants to be around 80% (up to 92%) after one year and 60-80% complete retention in three years. The Cochrane review found that data on effectiveness of sealants "in reducing caries is clear." However, the reviewers echoed what the NIH Consensus panel had found that the quality of evidence "concerning pit and fissure sealants was poorer than expected." (p.10)

2.6.2.4 Oral Health in America 2000

The fourth key review of literature undertaken regarding dental caries was part of the *Surgeon General's Report 2000* (USDHHS 2000). The Report described school-based sealant programs as one of its recommended strategies for preventing dental caries. It used Llodra's pooled analysis from 17 studies of one-time sealant application on permanent teeth of people who were not given any other preventive services (Llodra 1993).It found sealants to reduce caries by over 70% (p.166). It also quotes NIH (1984)

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[4] Two main types of sealants are: resin-based and glass ionomer cements. The latter are less used because of poor retention. Resin-based sealants are described as generations where first generation were activated by ultraviolet, second and third by visible light and fourth generation sealants containing fluoride in addition (Ripa 1993).

that “ a sealant is virtually 100 percent effective if it is fully retained in the tooth.” The Surgeon General’s Report showed a higher retention rate for sealants than shown by the Cochrane Review. It reported 92-96% retention after 1 year, 67-82% after 5 years, and even 41-57% after 10 years. (p.167)

2.6.2.5 Other Reviews

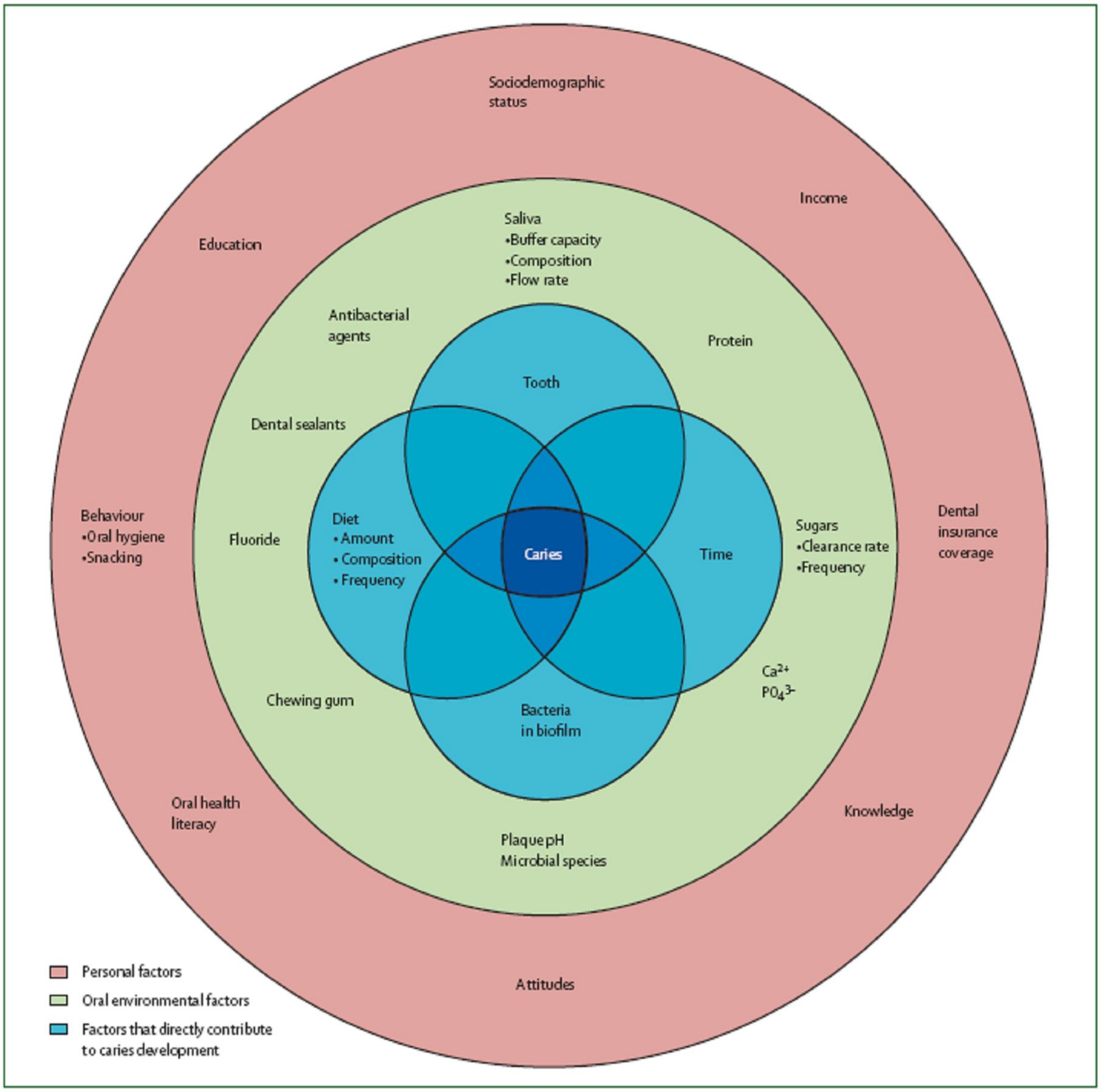
These were some of the key systematic reviews of evidence on the role of sealants in preventing dental caries. There have been other reports and studies that have looked at evidence on sealants and dental caries. We searched the University of Michigan Database/ Proquest database of dissertations and reports.[5] Only 6 dissertations were found in the database when the search terms [dental caries AND Hispanic OR minorities] were used. None of them was close to the topic of this dissertation. Similarly only three results were achieved when the terms [dental caries OR tooth decay AND Hispanic] were used. None of these studies were related to sealants in school-aged Hispanic children. They were all related to early childhood caries. Different search terms were used but none of the previous work was found to be close to the work in our study.

A recently published article focused on the topic of dental caries and summarized the evidence for physicians (Selwitz 2007). Selwitz et al describe the pathology of dental caries and outline the different types of risk factors for dental caries. They group these risk factors into physical, biological, environmental, behavioral, life-style related factors such as high numbers of cariogenic bacteria, inadequate salivary flow, insufficient fluoride exposure, poor oral hygiene, and poverty (Featherstone 2003). The list of factors that may affect dental caries status are many. The article goes on to add more social and cultural factors such as poor dietary habits, poor hygiene, poverty or social status, number of years in education, dental insurance coverage, and use of dental

[5] Proquest/UMI database. http://www.il.proquest.com/products_pq/descriptions/pqdt.shtml

sealants (Kidd 2004, Featherstone 2003, Ramos-Gomez 2002). The authors summarize the various factors causing dental caries in Figure 2.8 below.

FIGURE 2.8: Factors involved in dental caries development



Source: Selwitz 2007

2.7 DENTAL CARIES AND SYSTEMIC ILLNESSES

As people start living longer in the United States, the prevalence of oral disease is also likely to increase. As the number of adults with oral disease increase, it is also likely that incidence of oral disease complications linked to systemic illnesses may also increase (Slavkin 2000). Evidence collected over the last decade has shown a possible link between dental infection and the risk of cardiovascular disease including atherosclerosis and thrombosis (Epstein 1999, Valtonen 1999). Similarly there are studies that have found chronic dental infections associated with increased risk for cerebrovascular ischemia (Beck 1998). In one study those with poor dental status had a 2.6-fold increased risk of stroke (Grau 1997). In other studies dental infections have been linked with significantly increased risk for pre-term, low-birth weight-infants (Dasanayake 1998; Offenbacher 1996). Other diseases related to dental health include Sjögren syndrome (Fox 1998) and pneumonia and bacteremia in intensive care patients (Fourrier 1998). More research is required to establish causality in many of these associations.

2.8 CONCLUSION

The importance of preventive dental health policy for promoting oral health is well established. As shown above there is significant evidence about the strategy that works for reducing dental caries in children at a population level. Fluoridation and dental sealants have the strongest evidence to support their effectiveness in increasing the resistance of tooth enamel to subsequent cariogenic attacks. While fluoridation is achieved through water fluoridation at the community level and through toothpastes and varnishes, the dental sealant intervention is most effectively done through school-based or school-linked programs. Most dental sealant studies for dental caries prevention do not focus on Hispanic children, although demographic data on dental caries show a significant difference in the prevalence and etiology of disease in this subpopulation. School-sealant programs are mainly funded through public funds and therefore, it is imperative that school-sealant programs are studied from a public policy perspective in Hispanic populations. If regular preventive services are provided to school children, it is likely that their dentition will remain intact throughout adulthood with proper, supportive and inexpensive care (CDC 2005).

Chapter 3: Epidemiology of Disparities in Dental Caries in Hispanic Children

3.1 MAGNITUDE OF THE PROBLEM

World Oral Health Report 2003 describes oral disease as a major public health problem in all regions of the world (WHO 2003). Structural, financial and personal barriers limit the dental preventive and curative services accessed by populations around the world. According to WHO, 60-90% of school-children and the majority of adults in the world are affected by dental caries. Severe periodontitis (gum disease) affects 5-15% of most populations. WHO's report on oral health in schools reports that 90% of 12-year-olds in Portugal and 100% of 12-year-olds in Niger have signs of periodontitis (WHO 2003). Such high prevalence rates of dental disease are not confined to developing countries. Childhood dental caries is the most common chronic disease in the United States. Over half of 5- to 9-year-olds have at least one filling or cavity and this number goes up to about 78% for 17-year-olds and 85% for adults 18 or older (US DHHS 2000).

Based on National Health and Nutrition Examination Survey's (NHANES) most current data the Centers for Disease Control and Prevention reported that in children aged 2-11 years, 41% had caries in their primary teeth. But about a fifth (21%) of children in this age group had untreated tooth decay in their primary teeth. For children aged 6-19 years, 42% overall had caries in their permanent teeth, thus showing no difference in prevalence of dental caries in primary and permanent teeth in the population. The disease distribution only gets worse in adults. NHANES data shows that about 91% dentate adults[6] over the age of 20 years had caries experience. It was lower in persons aged 20-39 years (87%), than with those aged 40-59 years (95%) and ≥ 60 years (93%).

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[6] Approximately 8% of adults aged >20 years have lost all their natural teeth (called edentulism), this includes 25% of over 60 years old.

Based on NHANES III, only a third of children and adolescents (32%) aged 6-19 years had at least one sealant application on their permanent teeth.[7] Of all the teeth that had sealants, 85% were on molars. The 32% prevalence of dental sealants in permanent teeth of children and adolescents is still way off from the Healthy People 2010 objectives of 50% (CDC 2005).

Epidemiological estimates in Surgeon General's Report of 2000, which were also based on NHANES III data, showed more severe dental caries problem in America. It found that poor Mexican American children aged 2-9 years have a 71% dental decay prevalence compared to 67% in blacks and 57% in whites. It noted that even the ethnic group with the lowest untreated caries, non-Hispanic whites with higher family income, had 37% untreated caries. Poor adolescents 12- to 17-year-olds have higher untreated dental caries in permanent teeth than higher income adolescent groups.

It is also observed that the burden of dental caries is usually shared by a relatively small proportion of the population. 25% of children aged 5 to 17 years with at least one permanent tooth, account for about 80% of the total dental caries in that age group. At age 12, 25% of children account for 75% of caries and by age 17, 25% of adolescents account for 60% of caries in that age group (Brown 1996).

3.2 Disparities in Dental Caries

3.2.1 Racial and Ethnic Health Disparities

Racial and ethnic minorities, including Hispanics, bear a disproportionate share of chronic disease burden in the United States. According to CDC estimates in 2001 only 65% of Hispanics under the age of 65 had health insurance, compared to 88% non-Hispanic whites and 84% of the total population. With roughly 39 million Hispanics living in America as per the 2000 census, this is a significant number. Obesity in

[7] In 1988-1994 only 20% of children and adolescents had at least one sealed tooth. In 1999-2002 a 13% increase was reported. (CDC 2005)

Hispanic males is 7% higher and in females is 32% higher than their white counterparts (CDC 2004).Years of potential life lost due to stroke, diabetes, HIV, and chronic liver disease was higher in Hispanics under 75 years than whites. These trends are also seen in Texas, where the rate of pertussis is twice as high among Hispanic infants as among other children. The rate of obesity among Hispanics (67%) is higher than the overall rate among all Texans. The rate of teen age pregnancy in Texas is also higher in Hispanics compared to other ethnic groups (NCTPTP 2007).

Oral health in Hispanic population is of particular concern because the Hispanic population is demographically different by being younger than other ethnic groups. They are also the fastest growing ethnic group. Hispanics are estimated to become the largest minority group in the United States by 2020 (US Census Bureau 2000). Hispanic children are the largest group of children in the United States, comprising 16% of under 18-year-old population (US Census 2000). In California, more than half of all children will be Hispanic by the year 2010 (State of California 2002). Hispanic children in the United States' border areas are increasing in number rapidly because the region is generally experiencing a high population growth rate (THECB 2004).

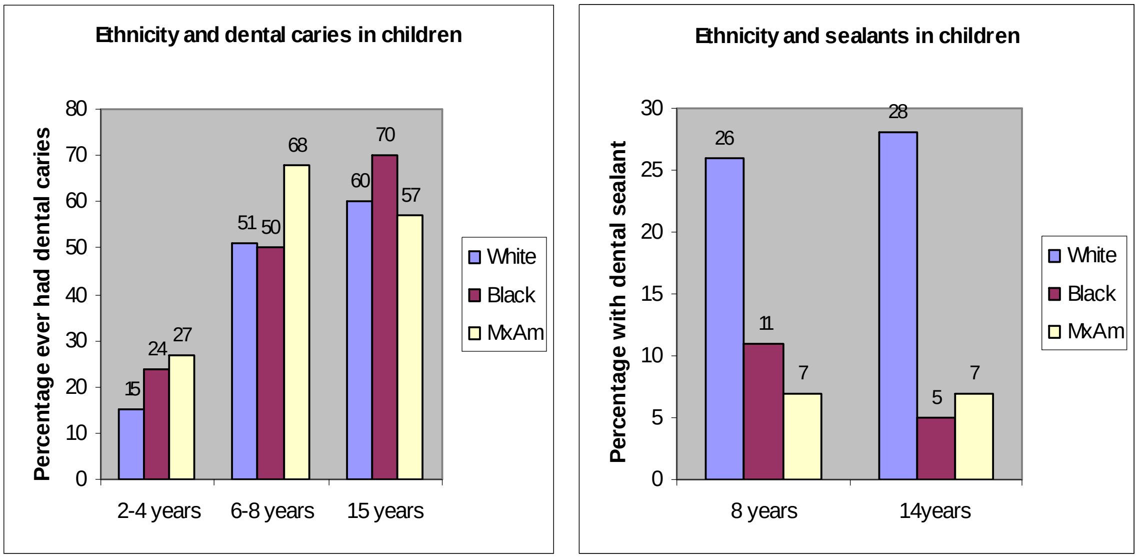
In 2004, the combined minority populations in Texas surpassed the size of the non-Hispanic white population. On its own, the Hispanic population is projected to become the majority population in Texas by year 2026. The largest growth in populations in Texas in the last decade has been in the minority populations. The median age for non-Hispanic whites in Texas in 2000 was 38 years compared to 30 for African Americans and 25 for Hispanics (DSHS 2004). With dental caries being by far the most common chronic disease of childhood in America, it is a major policy concern that the disparities in oral health, if not remedied, will very soon start reversing the gains of the past several decades (US DHHS 2000).

The Centers for Disease Control and Prevention (CDC) used NHANES data[8] to highlight these disparities for dental caries in the US population. In 2- to 11-year-olds, Mexican American children had the highest caries experience (55%) compared to 43% in blacks and 38% in whites. Also, Mexican American children had the highest untreated caries (32%) as compared to whites (18%) and blacks (27%) in primary teeth. In children and adolescents aged 6-19 years, Mexican American children had the highest caries (49%) compared to 40% in whites and 39% in blacks. The 6- to 19-year-old Hispanics also had a higher rate of untreated caries (22%) compared to much lower rates in whites (11%) and blacks (18%). As far as dental sealants are concerned, Mexican Americans and blacks were less likely (23%) to have at least one sealed tooth than whites (28%) (CDC 2005). Some of these disparities are shown in Figure 3.1. Another study showed that sealant prevalence in 14-year-old Hispanics was much lower (7%) than the national average (24%) in the same age group (Flores 2002).

Interestingly some of these disparities are reversed in adults for reasons not clear. For instance in dentate persons aged $\geq$ 20 years, non-Hispanic whites have higher caries experience (93%) than Mexican Americans (84%) (CDC 2005). However, as far as untreated dental caries, Mexican Americans still had higher untreated tooth decay (36%) than whites (18%). Blacks have the highest untreated caries (41%) among adults (CDC 2005). The Surgeon General's Report of 2000 also found that the percentage of untreated dental caries in poor Mexican Americans and blacks is more than twice that in whites (21%).

[8] which basically divides race into non-Hispanic whites, non-Hispanic blacks, Mexican-Americans, and others

FIGURE 3.1: Ethnicity and dental caries in children



Source: CDC 2005. Disparities in Oral Health.

Even in early childhood, Hispanic children have a higher incidence of caries than other ethnic groups. Almost 13% of Hispanic children examined in San Antonio and 37% of mainly Hispanic children in San Francisco had caries (Surgeon General 2000). Similarly, national survey data suggest that Mexican American children aged 12-23 months have higher caries than children of the same age in other ethnic groups (Kaste 1996). As a result only 30% of Mexican American school-aged children are caries free overall (CDC 2005).

Data on Hispanic health, particularly oral health, is not complete. Hahn (1992) lists three main reasons for deficiencies in Hispanic health profiles: insufficient sampling of Hispanics in national surveys, inconsistent or inadequate assessment of ethnicity, or ambiguities in reporting of ethnic identity. Within Hispanic ethnicity, for instance, there are differences in habits and norms among Mexican Americans, Cuban Americans and Puerto Ricans. Only the Hispanic Health and Nutrition Examination Survey (HHANES

1982-84) conducted more than 20 years ago, differentiated among these groups within Hispanic ethnicity. That survey found that Cuban Americans and Puerto Ricans had twice as many missing teeth and periodontal disease as Mexican Americans (Ismail 1990). The reasons for these differences are not apparent.

3.2.2 Border Health Disparities

3.2.2.1 U.S.-Mexico Border Health Issues

Hispanic health issues are increasingly affecting the overall health profile of the United States because Hispanics comprise an increasing share of the younger population in the country. This is particularly true of the southwest border between Mexico and the United States. The US-Mexico border comprises 20 counties in Texas, 6 in New Mexico, 4 in Arizona, and 2 in California. These 32 counties are home to 6.5 million people of which 1.8 million are children. Close to two-thirds or 62% of these children living on the border are Hispanic. The Hispanic children on the border bear a disproportional burden of poverty and deprivation. Among the poorest 100 counties in the nation 13 are among border counties. There are half a million children in border counties who live below poverty, 83% of them being Hispanic. The 37% child poverty rate for Hispanic children living along the border is more than twice the national child poverty rate of 17%. Also, the Hispanic school drop out rates of 15% are three times higher than that of whites (5%) living along the border (ACF 2005).

The Hispanic children in the United States' border area experienced a double digit population growth rate between 1990 and 2000 (DSHS 2004). Thirty-six (36) percent of the Hispanic border population is under the age of 18 compared to only 19% of non-Hispanics. The population trends in Texas are also similar. In 2004, the combined minority populations in Texas surpassed the size of the non-Hispanic white population. On its own, the Hispanic population is projected to become the majority population in

Texas by year 2026. The largest growth in populations in Texas in the last decade has been in the minority populations. The median age for non-Hispanic whites in Texas in 2000 was 38 years compared to 30 for African Americans and 25 for Hispanics (DSHS 2004).

3.2.2.2 Border Health Disparity in Texas

In 2001, Texas Comptroller published a report that highlighted the disparities in selected border counties, the 32-county federally-defined border counties from the La Paz Agreement with Mexico,[9] 211 non-border counties and the state of Texas. The following facts show the extent of disparity in socioeconomic indicators in border counties and the rest of the state:

- The poverty rate in the border region was 34% as against 14% for the nonborder counties and 17% for Texas.
- 41% of 5- to 17-year-old schoolchildren in the border counties live in poverty as against only 19% in nonborder and 22% in Texas.
- The unemployment rate was 11% as against 4% and 4.6% in nonborder and Texas respectively.
- The annual population growth rate in the border counties was 3% as compared to 1.9% in nonborder counties.
- Average annual pay in the border counties was $22,368 compared to $33,712 in nonborder counties and $32,254 in Texas based on 1999 data.
- Per capita personal income in the border region was about $14,224 while in nonborder region of Texas is $27,165 (Texas is $25,803).
- The proportion of children under 19 who were uninsured was 31% in border region and 24% in nonborder region.

[9] La Paz counties include the actual border counties and any county within 100 kilometers of the Rio Grande.

Added to the above mentioned health disparities is the fact that approximately 29% of the population of this 43-county border region has no health coverage. Children under 18 years also share the same rate of undercoverage (29%). The mean for the remainder of the state is 22% (THECB 2004). The Health Disparities Task Force that was created by the 77th Legislature House Bill 757 identified disparities in immunization coverage, diabetes, responsible healthy behavior, and other such health indicators (Valdez 2004). The University of Texas Health Science Center at Houston conducted a study called the Lower Rio Grande Valley Community Health Assessment and found significant deficiencies in public health infrastructure and overall health status in the border region (Perkins 2001). The counties of Cameron, Hidalgo, Starr, and Willacy constituted the assessment region.

Other studies and reports have also found signficant dental health disparities in the border region of Texas. Cappelli (2004) has identified several of these reports including a report "Make Your Smile Count" in 1998 by the University of Texas Health Science Center, San Antonio and community assessments in Arlington and Houston areas. Studies by Michael Najera in El Paso and Ramon Baez in Lower Rio Grande Valley show similar low oral health status among children in the border region. It is also worth mentioning that due to a significant number of illegal immigrants residing in these areas,[10] their dental and health status is often not reflected in surveys and community health assessments. These people and their children only access the healthcare system through emergency services,[11] when extractions and oral surgeries are needed. So we do not get any systematic information about dental caries or periodontal disease prevalence

[10] In 2000, the Immigration and Naturalization Service apprehended over 1.5 million undocumented immigrants, which are only a fraction of the actual numbers in the United States.

[11] According to American Hospital Association's annual survey, southwest border county hospitals reported uncompensated care totaling nearly $832 million in 2000. MGT of America in a report determined almost $190 million worth of uncompensated costs in emergency medical treatment for undocumented immigrants. (MGT of America. Medical Emergencies: Cost of Uncompensated Care in Southwest Border Counties. September 2002).

in these children. It is therefore reasonable to assume that the reported dental and health disparities probably understate the actual magnitude of the problem.

The changing demography of the border area needs to be taken into account in any health policy planning. A deeper understanding of the minority population's health needs and the delivery mechanisms that will overcome their barriers to access are essential for improving the health of these people. The Hispanic population in the border is not only getting larger but also younger and its higher growth rate is shifting the demographics to younger ages. While the aging baby boomers are driving increasing costs on chronic diseases such as diabetes and cardiovascular diseases, a younger population provides an opportunity to control future costs by preventing chronic diseases through early interventions.

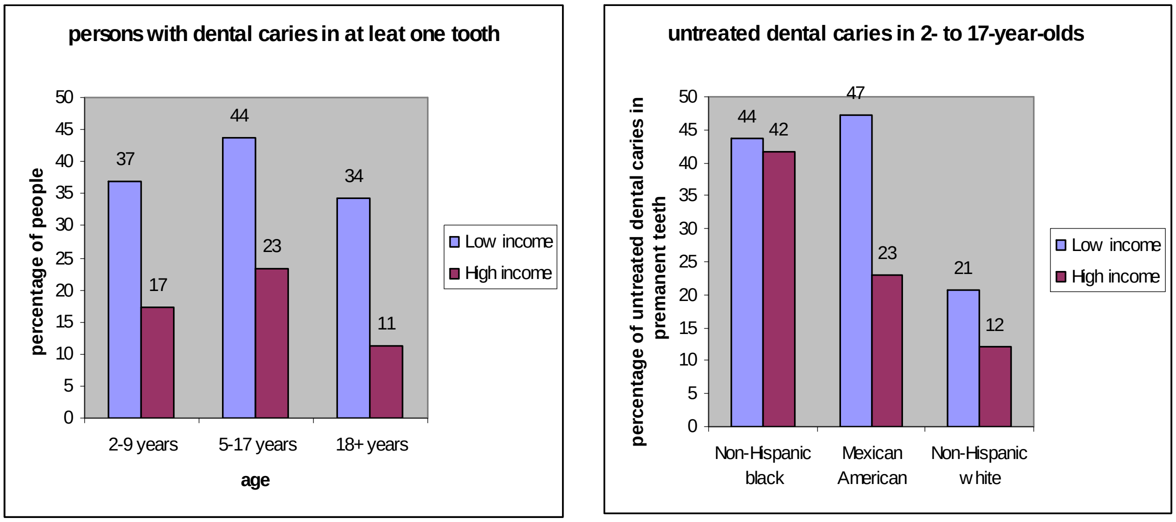
3.2.3 Dental Caries and Income

Dental disease and lack of dental care combine to affect the overall health, growth and development of children (Sheiham 2006). These effects are most prominently seen among low-income preschool children, who are twice as likely to have dental disease as are affluent children. Medicaid-eligible children who have dental caries or cavities have twice the number of decayed teeth and twice the number of visits for pain relief but fewer total dental visits, compared to children coming from families with higher incomes (Eldestein 2002). Fewer preventive visits for services such as sealants increase the burden of disease in low-income children. These disparities continue into adolescence and young adulthood, but to a lesser degree. The fastest growing populations of children are those that currently have the highest disease rates and the lowest amount of dental care. If the strong correlation between these subpopulations and dental diseases continues, caries rates are likely to rebound after longstanding declines and the stress on publicly financed dental care will likely increase (Eldestein 2002).

Children from families with more than double the federal poverty threshold (FPL)[12] had lower caries (31%) to those with lower income than 55% below FPL. Similarly, children aged 2-11 years living below FPL have much higher (36%) untreated tooth decay as compared to those with more than double (≥ 200%) the FPL (13%). Lower income children and adolescents (< 100% FPL) aged 6-19 years also have higher dental caries prevalence (48%) in their permanent teeth. Those with higher income have only 36% untreated caries. Lower income children also have higher untreated caries (19%) compared to only 8% for higher income children and adolescents. Higher family income children and adolescents between the ages of 6 and 19 years are more likely to have at least one sealed tooth than those with low family income (CDC 2005).Differences in income levels and dental caries based on NHANES data are also shown in Figure 3.2.

[12] There are two measures of poverty. The US Census Bureau uses the term Federal Poverty Threshold for statistical purposes. Department of Health and Human Services recommends the use of the term Federal Poverty Guidelines for income-levels that are used for determining eligibility for various administrative programs. It is published in the Federal Registry each year. The use of the term Federal Poverty Level is used by some to describe both or any of these levels. 2007 Federal Poverty Guidelines estimate the household income for a family of 4 in the 48 contiguous states in the United States as $20,650 and for a family of 5, $24,130. http://aspe.hhs.gov/poverty/06poverty.shtml

FIGURE 3.2: Disparities in oral health by household income



Source: Surgeon General's Report 2000

Surprisingly the difference in dental caries based on income levels is reversed in dentate adults over the age of 20 years. Higher income adults have higher dental caries (93%) than low income adults (87%). However this reversal does not show in untreated caries prevalence. Dentate adults with untreated caries are more common in those with low family incomes (41% in <100% FPL) than in higher family income adults (16% in ≥ 200% FPL) (CDC 2005).

An Agency of Health Research and Quality (AHRQ)-supported study analyzed Medical Expenditure Panel Survey (MEPS) data and found that poor and near-poor children aged 18 and under were only half as likely to have had a preventive dental visit as children in middle or high income brackets across racial/ethnic groups (Stanton 2003). A study of inner-city Hispanics in Washington DC in 1995 found that 47% of 2- to 5-year olds had caries with 18% of all children in need of immediate dental care (Watson 1999). In a survey conducted by the Texas Department of Health's (TDH) Office of Border

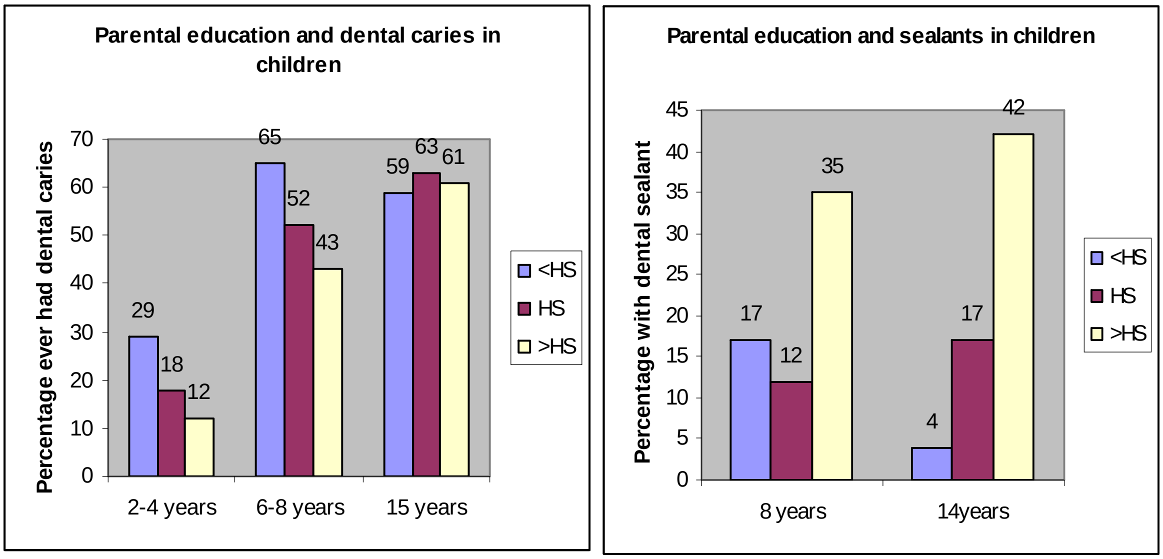
Health, 83% of the population living in the *colonias* (areas within 100 miles of the border with inadequate infrastructure facilities) was Hispanic and 34% was under 18. The majority (64%) of colonia residents did not have health insurance and only 36% reported having seen a dentist in the past (THECB 2004).

Preventive care, which is not very expensive, is also less accessible to children from low income families. Water fluoridation, which together with dental sealants, is one of the most effective ways of reducing dental caries in a population, is only available to 62% of community water supplies in the United States (CDC 1993). Fluoridation does not prevent all caries but significantly reduces the occurrence. The other major preventive strategy for dental caries in children is application of sealants, particularly on the chewing surfaces of teeth. However, only 12% of children living below poverty had at least one sealant, which is three times less than the prevalence in children from higher-income families (Flores 2002).

3.2.4 Dental Caries and Education

Disparities in oral health status and access to dental care are also evident when comparing children of parents with low educational attainment to children of parents with higher educational attainment (Eldestein 2002; Swank 1986). Prevalence of untreated dental caries in dentate adults over the age of 20 years was inversely related to their educational level. Higher educated adults had only 14% untreated caries as compared to 41% in those with less than high school diploma (Surgeon General 2000). Kenney (2000) used estimates from 1997 National Survey of America’s Families (NSAF) to report that children whose parents had not completed high school degree were 11% more likely to have had no dental visit in the last year than children of high school graduates. The Centers for Disease Control and Prevention has gathered data from different national surveys to compile oral health disparities among children and adolescents. Dental caries and absence of sealant application in children and adolescents are correlated with parental education (Figure 3.3).

FIGURE 3.3: Parental education, dental caries and sealants in children



Source: Centers for Disease Control and Prevention.2005. Disparities in Oral Health

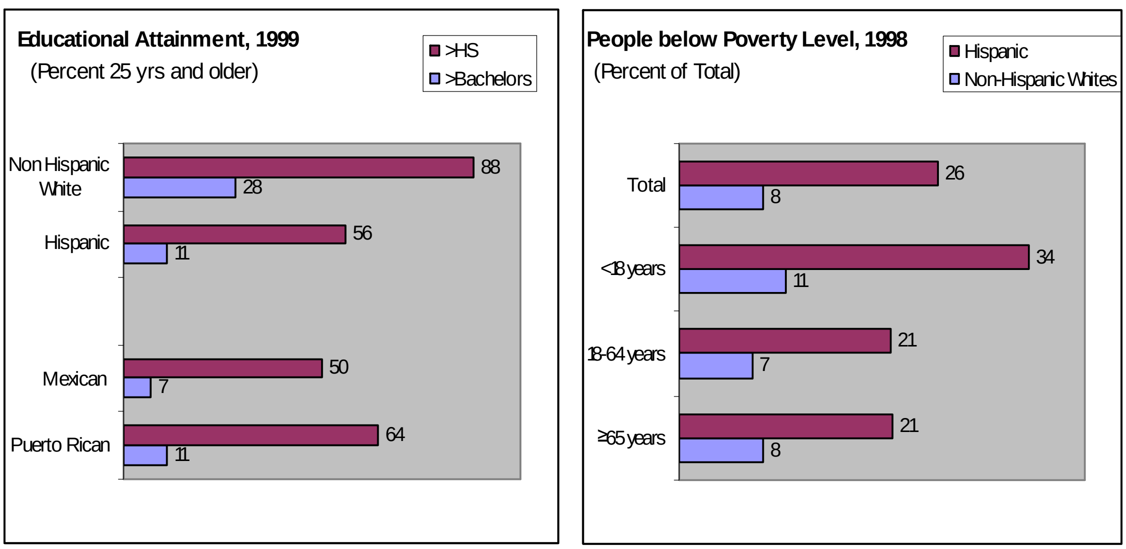
3.3 CAUSES OF DENTAL DISPARITIES

Next we analyze the possible factors that contribute to such disparities in dental caries. Unfortunately national data on tooth decay in children is patchy because many states do not have an oral health surveillance system. Dental caries remains the preeminent oral disease of childhood so tooth decay has been used as the primary marker for children's oral health. National data is available on dental office visits and therefore visits to the dentist are used as the marker for dental care utilization. In general, children from low-income families experience the greatest amount of oral disease and the most extensive disease. Yet these children also have the fewest overall dental visits.[13]

[13] Interestingly, children living below federal poverty levels (living in households with annual gross incomes under $17,000 for a family of 4) or those below 200% of federal poverty level (households with

Therefore, when we combine Hispanic ethnicity with low income families in rural areas, we are looking at some of the most underserved populations in this country. According to Ramirez (1999) the Current Population Survey (CPS) shows Hispanics are less likely (56%) to have high school diploma than non-Hispanic whites (88%), are three times more likely to be living in poverty (26%) than non-Hispanic whites (8%), and more likely to be unemployed (6.7% vs 3.6%). Figure 3.4 also shows that the disparity in income levels is maintained when comparing only Hispanic children (34% vs 11%) or Hispanic families (23% vs 6%) with non-Hispanic white children or families.

FIGURE 3.4: Disparities in income levels and educational attainment



Source: Ramirez 1999.(CPS data)

The Surgeon General's Report (2000) recommended that "Narrowing the gap in oral health between Hispanic and non-Hispanic groups require improved data on health

incomes between $17,000 and $34,000) have the highest rates of dental insurance coverage, primarily through Medicaid and SCHIP (Eldestein 2002).

status, barriers to access, and disease factors underlying differences in oral health in these populations” (p.76).

Ethnic differences relate to differences in culture, religion, nationality, and racial identification. These differences are manifested in the form of values, attitudes, behaviors, customs, rituals, and societal norms (Mindel 1981; Andersen 1997). Ethnic minorities have lower dental care utilization than white adults in the United States (Morey 1993; Ismail 1990; Hayward 1989) and studies suggest that these differences may be due to lower levels of education and less knowledge of oral disease prevention(Gift 1994). Research has also tried to explain the differences in oral health outcomes (tooth loss, dental caries) based on ethnic minority (Johnston 1993; Jones 1994).

The causes of disparities in oral health can be categorized into financial and nonfinancial. Financial causes will be predominantly related to low household income (Kenney 2005), dental insurance status (Manski 2001), and high out-of-pocket expenditure (Flores 2002). Nonfinancial causes will include limited Spanish-speaking dental health providers (GAO 2000), psychological barriers to getting Medicaid or other public support (Ryan 2003), less knowledge of benefits of preventive care (Swank 1986), sociocultural norms regarding oral health (Ismail 1990), and nutritional habits (Tinanoff 2000). Further causes would also include supply side factors, such as many Hispanics live in underserved areas where there is professional shortage (Flores 2003; Warner 2003). Many dental health professionals have a language barrier when dealing with low-income Hispanic parents (Hayes-Bautista 2007). Dentists are also not willing in many cases to accept Medicaid patients because of the low reimbursement rates (GAO 2000). Utilization of publicly provided dental coverage through Medicaid also has procedural impediments for low-income and less educated Hispanic parents (Flores 2002).

3.4 CALL TO ACTION BY SURGEON GENERAL

The Surgeon General unveiled the “Call for Action to Promote Oral Health” in 2003 – a document outlining public-private partnership proposals to fight dental disease and promote oral health (US DHHS 2003). The Call to Action revolves around a set of five principal actions to assure optimal oral health for all Americans. They include:

- changing perceptions of oral health care
- overcoming barriers to care using proven models and programs
- building the science base and accelerating science transfer
- increasing oral health care work force diversity, capacity and flexibility
- increasing collaboration between private and public entities involved in oral health

Such initiatives show an increasing awareness in policy makers of the role for oral health in the overall health of the nation and as an important part of the health policy of the country. Children are particularly at risk because habits developed during early years are the cause of most, if not all, the problems of oral health that develop in later years of life. Public policy needs to respond to this challenge and adopt policies and program that promote preventive care in underserved populations. Such policies will not only help in reducing the disparities in oral health in Latinos, African Americans and other minority children but also lay the foundation of a healthy generation of children for the future.

Chapter 4: Methodology and Data Collection

While dental caries is the most common chronic disease of childhood in America, it is even more common in certain subpopulations. One of these groups includes children of low-income minority families living in underserved areas. The area along the US-Mexico border is home to some of the poorest and least served Hispanic children in America. To study the impact of preventive dental care on the dental caries in such underserved populations, we selected a community close to the Mexico border in south Texas, where a unique dental examination project was being operated by the Center for Telehealth, The Texas A&M University Health Science Center, Dallas. It was a school-based screening program using teledentistry. The school where this project was introduced was Lyford Consolidated Independent School District in Willacy County.

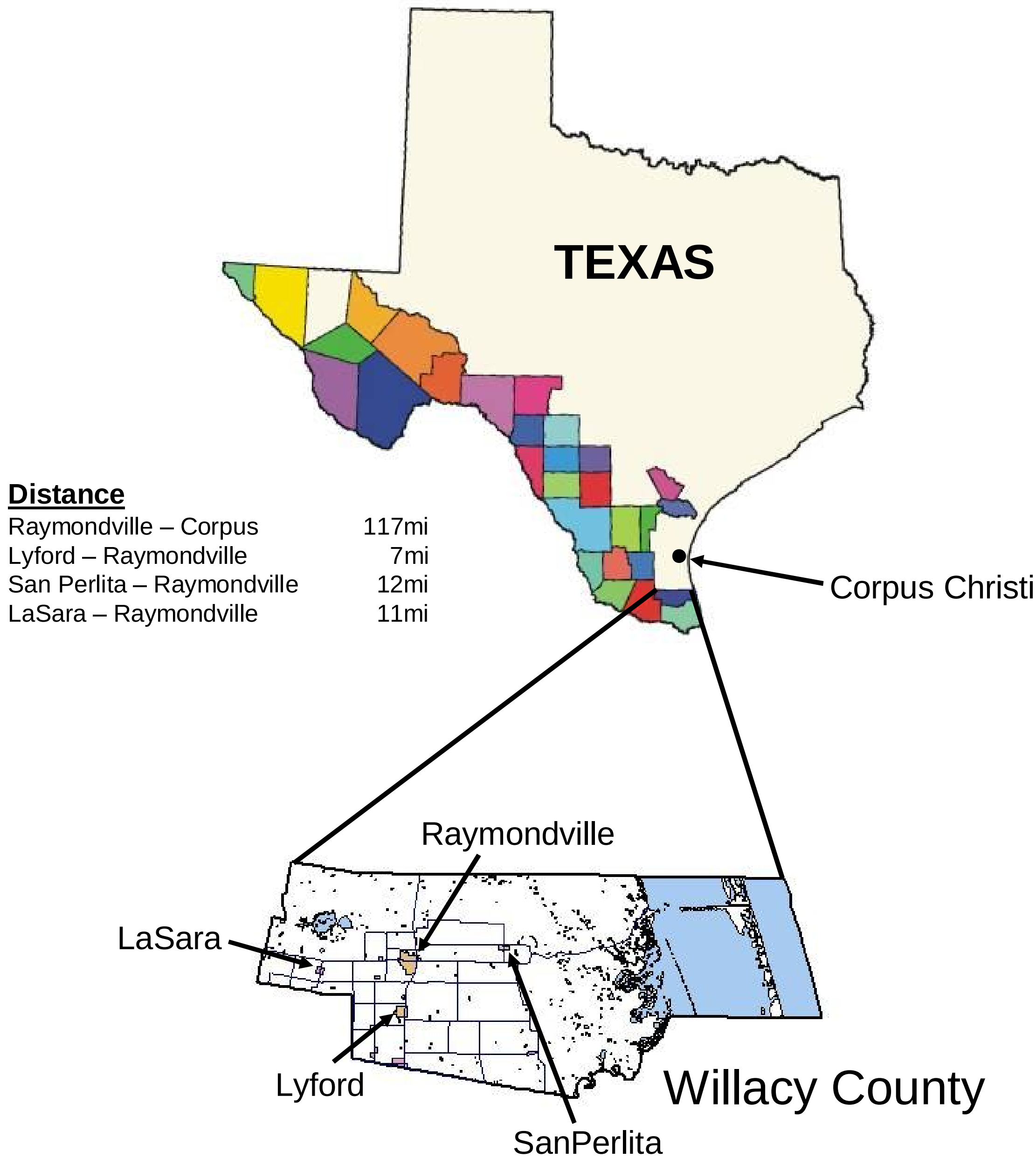
4.1 LOCATION AND CHARACTERISTICS OF STUDY POPULATION

4.1.1 Willacy County

Willacy County has an estimated population of 20,288 (DSHS 2002) and area of 597 square miles. 86% of the population is Hispanic. Almost 26% is below 14 years of age. The annual per capita income is $14,692 as compared to the Texas average of $29,039 (TDH 2007). It is a relatively poor area with median household income reported in 2003 to be $23,485, which is significantly below the state's average of $42,139. The unemployment rate is 18%, which is almost three times the state average of 6%. 32% of people who are younger than 20 have no health insurance. According to Census, 33.8% of the population lives below poverty. Of those below the age of 17 years, 43% live below poverty compared to 22% at the state level. The Average Monthly TANF (Temporary Assistance to Needy Families) recipients are 1,093 according to *Texas Health Facts 2002* (previously called *County Fact Sheet* at www.tdh.state.tx.us/dpa/cfsweb.htm). Average monthly Food Stamp participants are 5,690 and the number of Medicaid eligible people is 5,896, a number that has decreased between 1997 and 2002.

The health status of the population in Willacy County does not fare well compared to the rest of Texas. 32% of the mothers who gave births in the county had late or no prenatal care while that proportion for the state is 18%. The rate of sexually transmitted infections, such as chlamydia (almost only reported for females), was higher than the state average. The county has a dentist for over 10,000 people (Texas average: one dentist per 2,820). It is both a Health Professional Shortage Area and a Medically Underserved Area (DSHS 2007). The exact location of Willacy County may be seen in the map in Figure 4.1.

FIGURE 4.1: Location of the study site



4.1.2 Lyford School District

The public school enrollment in the fall of 2002 in Willacy County's four school districts was 4,663. Table 4.1 shows the school enrollment in 2003 in various school districts of Willacy County.

TABLE 4.1: Willacy County's school population

School	PK	K	1	2	3	4	5	6	7	8	9	10	11	12
Raymondville ISD	91	229	210	210	209	202	205	196	195	168	235	182	140	136
Lyford CISD	47	106	107	106	125	113	108	119	109	121	133	101	114	85
San Perlita ISD	17	12	20	21	20	19	19	15	19	21	18	23	12	16
LaSara ISD	6	39	39	25	26	32	32	28	29	26	26	1	0	0

Source: Center for Telehealth, Texas A&M University Health Science Center

The Lyford School District (as shown in Figure 4.2) has a total population of roughly 1500 students from pre-K to 12. Most of the children are Hispanic and many are from low income families. Almost 82% of the Lyford CISD population of children (about 1240) is classified as economically disadvantaged (TSPR 206). The Elementary, Middle, and High schools are contiguously located, as are the administrative offices of the Superintendent of Schools.

FIGURE 4.2: Lyford High School

4.2 TELEHEALTH PROGRAM AT LYFORD SCHOOL DISTRICT

The Telehealth program in Lyford school district was part of a network designed by the Center for Telehealth at Texas A&M University Health Science Center in 2000 under the visionary leadership of Dr. Lars Folke. The purpose of the program was to replicate, within the legal structure of the United States, successful European models of health care delivery to children through school-based clinics (Folke 2001). The approach is based on the evidence that has consistently shown that preventive services delivered at an early age are the best defense to control many chronic diseases including diabetes, obesity, and oral disease (Axelsson 2003).

The integrated network comprised a dental hygienist or nurse practitioner who is linked via a telecommunication link with the dentist or the physician. The dentist can supervise the dental hygienist via live mode or asynchronously. The telehealth program at Lyford mainly worked in the area of teledentistry and was linked to the local dentist (there are only two dentists in the entire county) for supervision. This was necessary because dental hygienists are not allowed to work independently in Texas without supervision of a licensed dentist. Also, while the school-based clinic could provide basic preventive care, any restorative or curative treatment required a referral to the local dentist.

FIGURE 4.3: Teledentistry facility at Lyford School Health Clinic

The teledentistry part of the network allowed the dental hygienist to transmit images of all the surfaces of the teeth and the condition of the surrounding tissues via a dedicated ISDN broadband line to the monitor screen of the dentist. Specially designed equipment (Figure 4.3) was used to allow such interactivity. The dentist could either look at the examination in live mode or asynchronously at his or her convenience. Digitally captured radiographs of the teeth could also be transmitted using state of the art radiology equipment. In cases where restorative, palliative, remedial or curative treatment was needed, the child would be referred to or called in by the supervising dentist.

In 2001-2002, after obtaining consent from all parents,[14] school children of all ages were examined by a dental hygienist under the supervision of a dentist. Those with severe disease were given a letter for the parents referring them to the supervising dentist or any other dental office for further treatment.

The teledentistry project received full support from the local school administration and the community.[15] Financial funding for the project was received from Baylor Oral Health Foundation, Dallas and United States Department of Agriculture's Rural Utilities Service Telemedicine Program, Washington DC.[16] With the help of the Lyford school authorities, the project successfully examined hundreds of students during its operation. During 2001-2002, almost 90% of the student body was examined at the clinic and their detailed oral profile was created. However, as funds dried up, the project could not continue and in 2003-2004 only a handful of students (less than 80) were examined at the clinic with a part-time dental hygienist.

[14] 89% of the parents consented while 11% refused mostly because their children already had access to regular dental care

[15] Superintendent of Lyford School District, Mr. Jack Damron and his colleague Ms. Irma Mondragon were extremely helpful in the teledentistry project and the parent survey.

[16] Baylor Oral Health Foundation, Dallas - $77,000 and USDA Rural Utilities Service Telemedicine Program, Washington DC -- $141,000.

4.3 SOCIODEMOGRAPHIC SURVEY OF PARENTS

To gather sociodemographic data of the student population that had been examined by the teledentistry project, we conducted a written survey of the parents of all school children enrolled in Lyford. As a research technique, survey research has considerable credibility in social science and professional disciplines (Rea 1997). Collecting economic data by using surveys filled out by patients (or in the case of minors by their parents) is a frequently used source of data in cost-effectiveness studies (van den Hout 2003). Best practices in conduct of health care research surveys identified by McColl (2001) were used in development of the survey instrument for this research. Rea and Parker (1997) describe survey methodology as a series of stages. They emphasize a step-by-step approach that goes through the following stages:

Stage 1: Identifying the focus of the study and method of research
Stage 2: Determining the research schedule and budget
Stage 3: Establishing an information base
Stage 4: Determining the sampling frame
Stage 5: Determining the sample size and sample selection procedures
Stage 6: Designing the survey instrument
Stage 7: Pretesting the survey instrument
Stage 8: Selecting training interviews
Stage 9: Implementing the survey
Stage 10: Coding the completed questionnaires and computerizing the data
Stage 11: Analyzing the data

Groves *et al* (2004) describe a similar strategy for what they term as "total survey error" paradigm of survey methodology and depict it as shown in Figure 4.4:

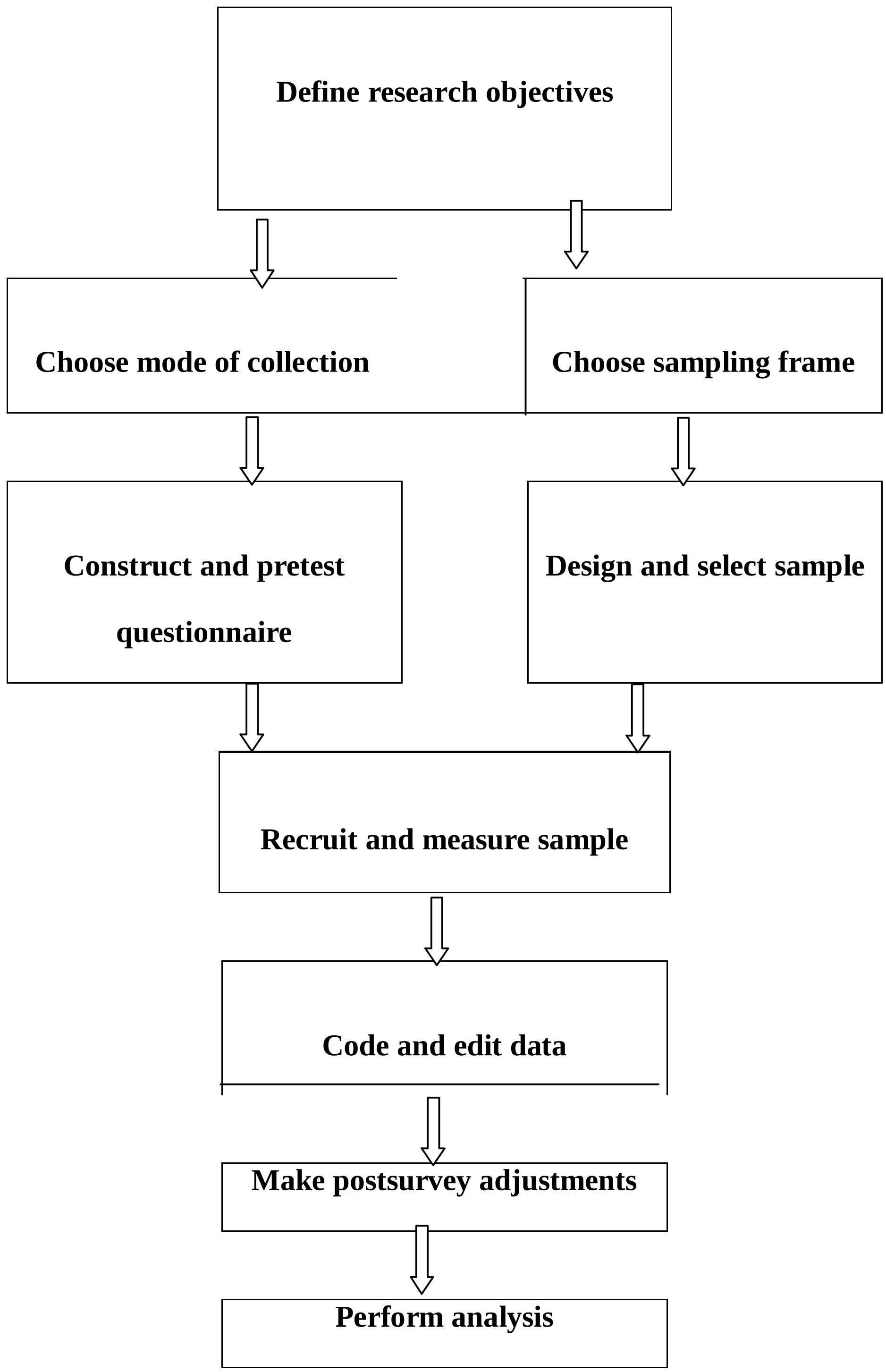


FIGURE 4.4: Survey methodology steps

Works by McColl (2001), Rea & Parker (1997), and Groves (2004) all emphasize a scientific and organized thinking to choose, develop and implement a survey methodology. The survey methodology and rationale followed for our research can be shown schematically as in Figure 4.5.

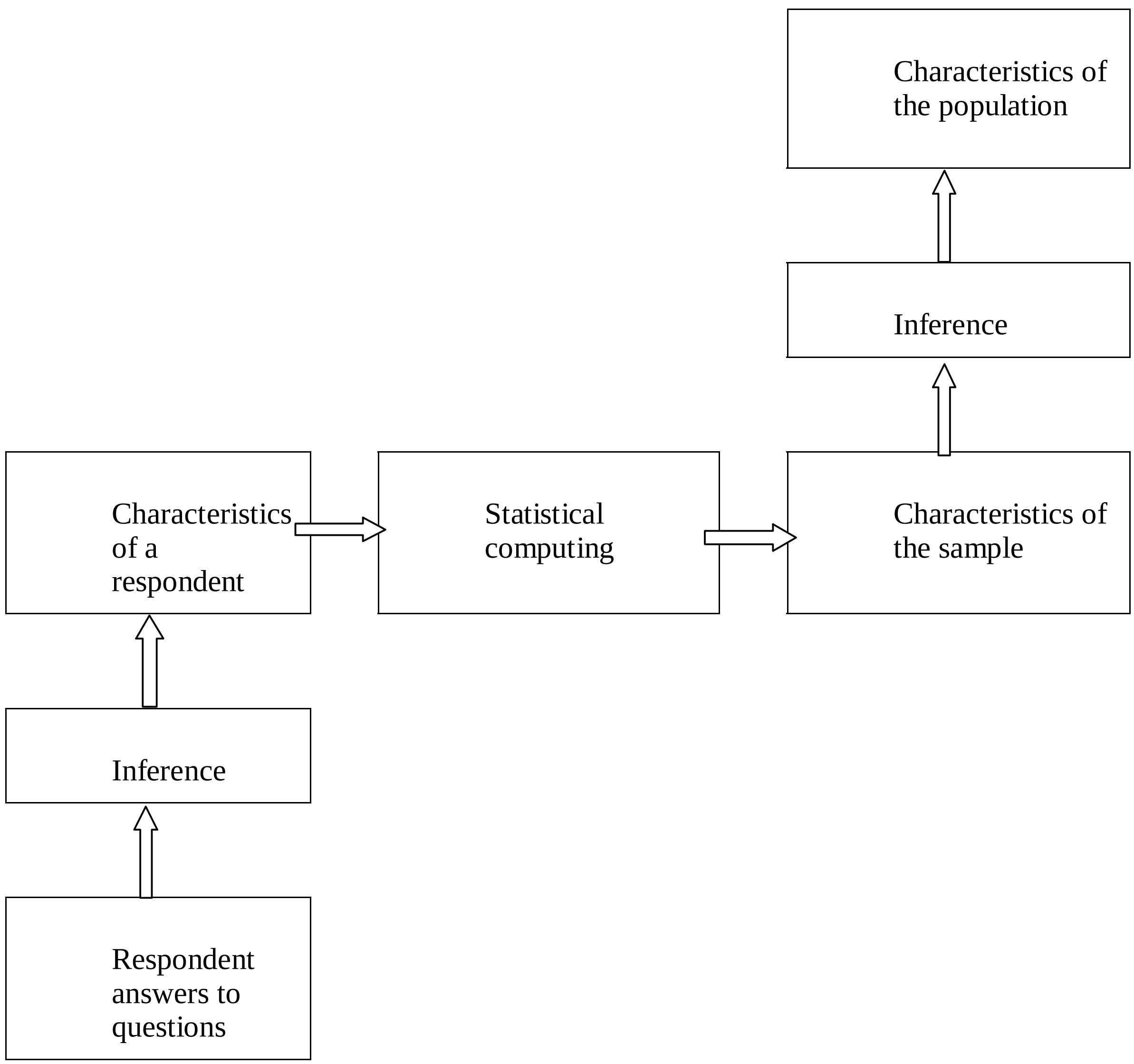


FIGURE 4.5: Schematic of inferential inquiry using survey methodology

The stages described by Rea & Parker were used to guide and implement the survey methodology for our sociodemographic data collection.

4.3.1 Data Collection

Meetings were held with administrators both at the school level and at the Center for Telehealth to discuss the format of the survey. Written survey questionnaires to be filled in by parents of the children turned out to be the methodology that was proposed as the best strategy by the key informants. In-person interview surveys and telephone surveys were other options considered but rejected because of time, cost and human effort required for completion.

The timing of the survey was key to working with children in a school environment. Response rates to mail-in surveys depend on several factors: sample size, length of the instrument, purpose of the study, nature of questions asked, language of the survey, credibility of the entity conducting the survey, and how the surveys are returned. Discussions with school officials and other researchers who have worked in the Texas border area indicated that survey forms delivered through teachers and sponsored by the school administration will lend a high degree of trust and credibility to the surveys and the response rates might be significantly increased compared to mail-in surveys. Therefore we decided to use written questionnaires to be hand-delivered to parents through school children.

Interviews and site visits were conducted to talk to locals including parents, school administrators, community workers, and health professionals at Lyford school district. As a result, an information base was established that included key contacts and how to reach them. At the same time presentations were made before the school district representatives and community leaders to develop buy-in from the school administration and parents.

Information on the insurance status, household income, distance from nearest dentist or physician could be obtained accurately only from the parents of school children. We expanded the scope of the survey by collecting some information about the parents that may be relevant to the children's health. The survey was therefore designed to be filled in by the parents. Since many parents in the population could not understand English well, it was decided that the survey needed to be in both English and Spanish.

4.3.2 Survey Instrument Design

The next step was designing the survey instrument. Factors to consider included

- number of questions: length directly affects the response rate, the longer the instrument the lower the response rate
- nature of questions: personal and sensitive questions also affect response rates, the more personal or sensitive the questions, the lower the response rate
- type of questions: whether open ended, multiple choice, or fixed length answers. Multiple choice questions usually are easier to answer and response rates are better. Usually categories or ranges help in response rates because respondents find it easier to commit to ranges in their answers rather than give specific numbers.
- language of the questionnaire both in its reading level and its language: difficult, ambiguous, or technical words in the survey instrument lower the response rates. Microsoft Word calculated an eighth grade Flesh Reading Index for the instrument developed for this study. Since many people in the border area, including Lyford

school district could only speak Spanish, we translated the instrument into Spanish so that language does not become a barrier in responding to the questionnaire. This translation was done by three different native speakers and reviewed by school officials at Lyford.

Questions on oral health used in national surveys and other studies of dental health services were used to identify the type of questions to be asked in the survey instrument. For instance, Andersen (1981) uses survey data collected at the University of Chicago to assess access to medical care by people of Spanish-heritage. Variables used in this study include having a regular source of care, wait at doctor's office, health insurance, frequency of visits to a dentist or physician, wait for an appointment, wait time in a doctor's clinic and the nature of interaction. Other variables were education of head of household, family income, and age.

Manning and Phelps (1970) study how demands for various dental services might differ and measure type of dental visit. Holtmann and Olsen (1976) in their study use variables such as number of dental visits by a household in last year, annual income, educational level of the head of household, time to travel to the dentist's office, waiting time per visit, and number of children under 16. They also have information on tastes and attitudes such as fear of the dentist. Garcia and Juarez (1978) studied dental care in Chicanos and Anglos using a 1973 household survey in Arizona. They include income, education, occupational status, sex, age, ethnicity, and poverty in their analysis.

Other considerations in developing the survey instrument included avoiding ambiguous concepts, technical jargon, multipurpose questions, and nonspecific words. Each question asked about one clear concept and it explained a term if it was not common. Introductory questions were about basic identification facts and meant to put the respondent at ease. Questions on similar topics were lumped together so respondents do not have to jump from one concept to another. The more sensitive questions were left to the very end with the words “optional” added within brackets. We did not want people to give up the questionnaire if they do not want to answer the more sensitive questions.

The survey (Appendix 4.A) comprised 48 questions that included questions about some information of the parents or whoever fills out the survey and the rest about the child who was a student in Lyford School. The survey did not ask for information about oral health status because oral health perception was not something that our research was measuring. Parents’ assessment of the oral health of their children is usually a very poor indicator of the actual health status (Friedman 1976). Only examination by a trained professional can be relied for oral health status.

4.3.3 Testing the Instrument

Once the survey was designed it was circulated to various professionals who work in the area of school health, health financing, health information, dental health and health economics. A pilot run was conducted with a group of parents who were attending a school event at Lyford. Seven parents filled out the survey and did not have any ambiguity about the questions. They took less than ten minutes, on an average, to complete the survey. Some of these parents could only read and understand Spanish.

4.3.4 Survey Implementation

The timing and method of the distribution of the survey were important decisions that could affect the response rate. The experience of local school officials was that mail-in surveys do not get a good response since people tend to treat letters requesting information as junk mail. However, parents do look at all the paperwork that is sent to them by the school especially at the start of the school year. A conference was held with the principals and other school officials at Lyford and the research objectives were explained to them. The school administration suggested that teachers be requested to send the surveys home through children. The school administration added a covering letter encouraging parents to respond to the survey. For maintaining privacy and confidentiality the parents were asked to return the surveys to the school office directly in sealed envelopes. The survey forms were distributed starting first October 2004 and accepted till the end of six weeks from the date of distribution.

The school enrollment was 1500 students from pre-kindergarten to high school at that time. Surveys were distributed to all students, and 870 forms were returned. Four of the forms were returned blank with only the name of the parent filled in. The overall response rate was about 60%, which is much better than normally achieved in mail-in surveys.[17]

Each form was assigned a unique identification number. The initial data entry was coded into Excel spreadsheet. The questionnaire had no open-ended questions, except for the first few questions about name, address, and date of birth, and four questions in the middle of the survey that asked for distance from the nearest dentist or physician. All other questions had categories that respondents had to check. So the response to each question was entered as numbers 1-5 depending on the number of categories. Data entries were checked for typographical errors. In cases where more than one forms came from the same family the responses of the parents were checked for internal consistency. A codebook was created that showed each variable and its values.

[17] Typical response rates of mail-in surveys is rarely more than 25%. See Krishnamurthy S. Email Surveys. http://faculty.washington.edu/sandeep/d/emailethics.pdf

4.4 DATA STRUCTURE

Although data were entered in a Microsoft Excel spreadsheet, the Stata statistical package was chosen to manage the data and carry out the statistical analysis. Table 4.5 describes the variables collected through the survey instrument. The final list of students containing their names and date of birth was also checked with school records to remove any mistakes in transcribing from handwritten responses in the completed survey forms and to make sure that double entries and wrong information is not accidentally entered in the survey forms or in the data set. The final tally of clean and unique records was 760.

TABLE 4.2: List of key variables from the survey

variable name	variable label
id	unique id
p_lname	parent's last name
p_fname	parent's first name
p_mname	parent's middle name
addr	address and city
zip	zip code
c_lnames	child's last name
c_fname	child's first name
c_mname	child's middle name
grade	child's grade
dob	student's date of birth
relation	relationship with child
c_dins	child's dental insurance
p_hins	parent’s health insurance status
knowmed	parent’s knowledge about their Medicaid eligibility
c_medelig	child eligibility for Medicaid/SCHIP
c_lastden	child's last dental visit
dtransp	transportation for child's dentist
c_dmile	distance to child's dentist in miles
c_dminu	distance to child's dentist in minutes
c_timeden	time off by parents for child's dental visit
payden	amount paid at last dental visit
c_crossden	cross the border for child's dental care
c_crossdrug	cross border for child's drugs or medicines
p_crossdrug	cross border for parent's drugs or medicines
p_crossden	cross border for parent's dental care
stayW	stay in Willacy County

p_bcountry	parent's birth country
c_bcountry	child's birth country
race	race
lang	language
worktype	type of work (full-time/part-time)
hincome	household total income
p_educ	parent's highest education

The final step in data collection was to match the records in the survey with the records from the dental examinations conducted by the teledentistry project. We explain the methodology in the next chapter.

Chapter 5: Effect of Preventive Care on Dental Caries in Hispanic Children

5.1 INTRODUCTION

Understanding the factors that may reduce morbidity or mortality in a population is important to formulation of effective health policy. This research focuses on oral health care in an underserved population and endeavors to understand the role of preventive care in reducing the incidence of dental caries in such populations. Without having the luxury of having accurate measures of oral health in the population at large, we use observable and measurable variables, such as incidence of dental caries, as proxy to oral health. The next step in our effort to understand the role of preventive care in the occurrence of dental caries in children is to use a measure of preventive care, which again is hard to measure directly and accurately. We use the presence or absence of dental sealants as a variable that gives us an indication of preventive care in the history of a child. This information is derived from the clinical examination of students in the teledentistry project at Lyford School District. Finally, through our written survey, we gather information about sociodemographic and economic factors that may also influence the oral health in children and adolescents.

This chapter presents the results of the dental examination and survey findings regarding dental caries and the role of preventive care and other socioeconomic factors. It also presents a model to explain the variation in incidence of dental caries in our sample and empirically shows the various factors that may explain the difference in incidence of dental caries in children in this underserved population.

5.2 MODEL SPECIFICATION

Our data analysis focuses on tooth decay or dental caries as an outcome. We use tooth decay, socioeconomic factors, and sealant application to estimate the effect of preventive oral care. Our hypothesis is that there is continuous tooth decay taking place in children and those students that have preventive care, as measured by presence of a sealant on any tooth, will have a lower incidence of caries than those without preventive care. Our choice of the policy variable, sealant application, has strong evidence of effectiveness in preventing dental caries in children as already discussed in earlier chapters. We want to measure the effect of such preventive care in mainly Hispanic population in an underserved area. To measure the effect of sealants on reduction of incidence of caries, we also take into account demographic and socioeconomic factors that may affect caries in children, such as child's age, sex, parent's education, and household income.

We are studying how socioeconomic and demographic factors influence dental caries in a certain population of children. We assume that the probability of a child having dental caries is determined by a latent unobserved response variable that denotes the true dental health status. We assume a latent or unobserved variable y^* that is related to the observed independent variables x_i by the structural equation:

$$y^* = x_i \beta + \varepsilon_i \qquad (1)$$

where i is the number of observations and ε is the random error term with mean zero.

The link between the observed binary dependent variable y_i (having caries or not) and the latent variable y^* can be shown with the simple equation:

$$y_i = 1 \quad \text{if } y^* > 0$$

$y_i = 0$ otherwise

So what we actually observe is whether a child has caries or not, i.e. 1 or 0 value, for the observed y_i. When y^* is positive, y is observed as 1, otherwise as 0.

The probability of observing y as 1 or 0 can be shown as,

$$\Pr(y = 1 \mid x) = \Pr(y^* > 0 \mid x)$$

which is the same as,

$$\Pr(y = 1 \mid x) = \Pr(\varepsilon > -[\alpha + x_i \beta] \mid x) \qquad (2)$$

Probit models estimate binary dependent variables by constraining the predicted values $\Pr(y=1 \mid x)$ to be within the range 0 and 1 (Gujarati 2003, p.608). The model assumes that the error term is independent and identically-distributed, has a mean 0 and has a normal distribution with Var (ε) = 1. The probability is calculated as (Long and Freese 2006, pp. 131-181):

$$\Pr(y = 1 \mid x) = \int_{-\infty}^{\infty+\beta x} \frac{1}{\sqrt{2\pi}} \exp(-\frac{t^2}{2}) dt \qquad (3)$$

The probit function uses the cumulative density function to estimate probability of the event occurring at different values. The estimation is carried out via maximum likelihood method.[18]

If we were to assume that the underlying probability is linear and use a linear probability model, it will give us a good estimate of the underlying non-linear model as well. But the key problem is that the marginal effects are kept constant. Predictions based

[18] Another option in such cases is to use logit model which assumes a different underlying distribution of the error term. The advantage of logit model is that it allows interpretation using odds ratio (also achieved by using logistic regression). According to Gujarati and Long and Freese, there is little difference between the coefficients of logit and probit models. We choose probit because Stata statistical software has user developed modules that can deal with the complexity of multivariate probit models.

on such models will give meaningless results when the latent variable is close to 0 or 1 since some of the predictions could be outside 0 and 1 interval (Arendt 2006).

In theory, dental caries may be determined by a host of socioeconomic, demographic, behavioral, genetic, and environmental factors. A review of literature found over 100 factors that have been studied for their influence on dental caries (Harris 2004). We are limited in using variables that are present in our survey and clinical data of the sample in Willacy County and must assume unobserved variables are uncorrelated with observed variables. The hypothesis of our study is that preventive dental care will reduce the number of school-aged children who have dental caries (variable *caries2*). Since we have no direct observation of preventive dental care we use a proxy for that variable, which is the presence of sealant (variable *seals*). A sealant cannot be self applied and shows a preventive procedure by a dental professional. So the simplest relationship can be shown as:

$$\Pr(\mathit{caries} \mid \mathit{sealants}) = \Pr(\varepsilon > -[\alpha + \beta_1\, \mathit{sealants}]) \qquad (4)$$

However, as discussed in detail in chapter 2 and 3, the probability of dental caries in a child or adolescent may also be affected by demographic factors such as age (*c_age*), sex (*sex*), and race (*race*) (CDC 2005, Selwitz 2007). In our sample almost all children are Hispanic, hence we do not use race or ethnicity as a variable, instead our analysis is limited to Hispanic populations. Additionally, socioeconomic factors such as household income (*hincome2*), parent's education (*p_educ3*), language spoken at home (*lang2*), duration of stay in the county (*stayw2*), and parent's country of birth (*p_bcountry2*) may also determine probability of caries in children (Kenney 2005, US DHHS 200, Harris 2004, Flores 2002). We also have data related to health and dental insurance status of parents (*p_hins* & *p_dins*) and their children (*c_hins* & *c_dins*), and Medicaid and SCHIP eligibility of children (*c_medelig*) that may also affect the probability of dental caries (Redmond 2006; Manski 2001; Seale 2003). Finally, the timing of the last dental visit (*dentfreq*) of the child may also theoretically affect the probability of dental caries because those who visit the dentists regularly are likely to have better health (Liu 2006; Vargas 2002). Hence, the structural equation we use to explain probability of dental caries in our sample is:

$$\Pr(\mathit{caries} = 1) = \Pr(\varepsilon > -[\,\alpha + \beta_1\,\mathit{sealants} + \beta_2\,\mathit{sex} + \beta_3\,\mathit{age} + \beta_4\,\mathit{parent's\ education} + \beta_5\,\mathit{household\ income} + \beta_6\,\mathit{parent's\ health\ insurance} + \beta_7\,\mathit{stay\ in\ Willacy} + \beta_8\,\mathit{parent's\ country\ of\ birth} + \beta_9\,\mathit{language\ spoken} + \beta_{10}\,\mathit{child's\ Medicaid\ eligibility} + \beta_{11}\,\mathit{child's\ dental\ insurance} + \beta_{12}\,\mathit{dental\ visit\ frequency}]) \quad (5)$$

or more simply,

$$\Pr(\mathit{caries} = 1) = \Pr(\varepsilon > -[\,\alpha + \beta_1\,\mathit{sealants} + \textstyle\sum_k \beta_k x_k\,]$$

where x_k are sociodemographic variables such as *sex*, *income,* and *parent's health insurance*. All variables are binary except age (*c_age)* variable which is continuous.

5.2.1 Concerns for Endogeneity in the Model

It is possible that there is an endogeneity in this model. As described by Wooldridge (2002, pp. 50-51) such endogeneity may be due to (a) omitted variables caused usually by data unavailability or inability to measure a certain characteristic; (b) measurement error where we are forced to use a proxy to measure a variable of interest; (c) simultaneity when the explanatory variable is determined by some of the same factors as those affecting the dependent variable. We suspect that sealant application and dental visit frequency may be candidates for being endogenous variables in this model. Ideally we would have liked to have details of each dental visit by each person in our data, so that it could be determined whether the visit was for preventive services or curative/treatment services. In the absence of such data, it is possible that dental caries was the cause of the visit in which sealant application occurred. Similarly, while regularity of dental visits can influence occurrence of dental caries, dental visits may also be the result of dental caries occurring first.

We first describe the equation of factors that may influence sealant application. It is possible that sealant application itself is determined by occurrence of dental caries. Other variables that may affect dental sealant application include variables that measure parent's knowledge of Medicaid and SCHIP eligibility (*knowmed2*) and their tendency to cross the border for medicines (*p_crossdrug*). These variables may actually correlate with the parents' concern for their health and the health of their children. For instance, we may assume that those parents who take interest in their own health or the health of their children and know whether their children are Medicaid-eligible have better health awareness (Macias 2001). The children's access to a dentist may also be affected by the availability of transport in a rural environment such as Willacy County (Guendelman 1991; Estrada 1990). We therefore use the variable that measures whether parents use their own car, public transport, or someone else's transport to go to the dentist (*dtransp2*). There are other socioeconomic factors that may also affect sealant application, such as household income (*hincome2*), health insurance status (*p_hins*), and stay in the county (*stayw2*). In multivariate analysis the equation for the endogenous variable *seals* will be a reduced form equation that has all exogenous variables from the structural equation for caries but without the outcome and endogenous variables as shown below:

Pr (*sealants* = 1) = Pr ($\varepsilon > \alpha + \delta_1$ *sex* + δ_2 *age* + δ_3 *parent's education* + δ_4*household income* + δ_5 *parent's health insurance* + δ_6 *stay in Willacy* + δ_7 *parent's country of birth* + δ_8 *language spoken* + δ_9 *child's Medicaid eligibility* +

δ_{10} *child's dental insurance* + δ_{11} *parent's crossing border for medicines* + δ_{12} *transport used for dental visit* + δ_{13} *knowledge of Medicaid eligibility*) (6)

or simply as,

$$\Pr(\textit{sealants} = 1) = \Pr(\varepsilon > \alpha + \delta_1\,\textit{caries} + \textstyle\sum_k \delta_k x_k)$$

where x_k include demographic and socioeconomic factors (exogenous variables) not in the first equation.

The other variable we suspect of being endogenous to the structural equation of dental caries is last dental visit (*dentfreq*). A dental visit might follow the occurrence of dental caries, hence *caries2* appears on the right hand side of this equation.[19] A visit by the parents across the Texas-Mexico border to get cheap drugs or medicines (*p_crossdrug*) may increase the chances of visiting a dentist because of difference in fees or convenience of seeing a dental professional who has the same language and culture. Similarly, availability of own transport (*dtransp2*) (Guendelman 1991) and knowledge about Medicaid eligibility (*knowmed2*) (Seale 2003) may also affect the timing of last dental visit. The socioeconomic factors that may affect dental caries are also likely to affect last dental visit and are therefore included in the reduced form equation for dental visit frequency.

Pr (*dental visit frequency* = 1) = Pr ($\varepsilon > \alpha + \lambda_1$ *sex* + λ_2 *age* + λ_3 *parent's education* + λ_4 *household income* + λ_5 *parent's health insurance* + λ_6 *stay in Willacy* + λ_7 *parent's country of birth* + λ_8 *language spoken* + λ_9 *child's Medicaid eligibility* + λ_{10} *child's dental insurance* + λ_{11} *parent's crossing border for medicines* + λ_{12} *transport used for dental visit* + λ_{13} *knowledge of Medicaid eligibility*)[20] (7)

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[19] A detailed discussion of variables that influence the last dental visit is presented in Chapter 6.

[20] dentfreq = last dental visit < 1 year ago, p_crossdrug=parent's crossing border for medicines, dtransp2=transport using my car, knowmed2=knowledge of Medicaid eligibility

or simply as,

$$\Pr\,(\textit{dental visit frequency} = 1) = \Pr\,(\varepsilon > \alpha + \lambda_1\,\textit{caries} + \textstyle\sum_k \lambda_k\, x_k)$$

where x_k include demographic and socioeconomic factors (exogenous variables) not in the first equation.

According to Baum (2006 p.185) a variable is endogenous if it is correlated with the disturbance term such that $Cov[x_i, \varepsilon] \neq 0$. If $Cov[x_i, \varepsilon] = 0$ then x_i is exogenous. OLS estimators are only consistent if $Cov[x_i, \varepsilon] = 0$ for i=1,2,….k. If endogeneity is present in our equations, we need to find instrumental variables to get consistent estimates. Such a variable should be uncorrelated with the disturbance term (orthogonality condition) but highly correlated with the main independent variable that is suspected of being endogenous. Given that caries or preventive dental care are influenced by a host of factors that have not been measured in our dataset directly, it is quite possible not to find good instruments in the data (Baum 2003). But before we search for instrument variables, we test using econometric methods whether endogeneity is a problem we need to adjust for.

The problem we face is that standard instrumental probit regression estimation in most statistical packages (eg IVPROBIT in Stata) work only with continuous endogenous variables on the right hand side of the structural equation. In this case, our endogenous variable, *seals,* is a binary variable hence we need to use a technique that deals accurately with binary endogenous variables. We use a Stata user written routine that estimates multiple equations probit models using maximum simulated likelihood method (Cappellari and Jenkins, 2003). The variance-covariance matrix of the cross-equation error terms has values of 1 on the leading diagonal and the off-diagonal elements are correlations to be estimated as rho_{ij}. The maximum likelihood method (SML) uses the Geweke-Hajivassiliou-Keane (GHK) simulator to evaluate multidimensional likelihood functions. The GHK simulator uses the fact that multivariate normal distribution function can be expressed in terms of sequentially conditioned univariate normal distribution functions. The GHK simulator uses random draws from standard normal distributions and recursively computes multivariate probability values through a process of replication. It then calculates simulated probability as the arithmetic mean of the values of the simulated probabilities from each replication. We use this procedure because the simulated maximum likelihood (SML) estimator is consistent in large samples and asymptotically equivalent to the true maximum likelihood estimator which cannot be easily computed. Our main interest in using multivariate probit models using GHK simulator is to perform postestimation tests for endogeneity when there are more than one right-hand side discrete endogenous variables in an equation.

5.2.2 Testing Endogeneity in Multivariate Probit Models

We first test for endogeneity between dental caries and sealants using a bivariate probit regression that fits a maximum likelihood two-equation probit model. Our bivariate probit model is built on a first structural equation determining the outcome variable (*caries2* in this case) and a second reduced form[21] equation for the potentially endogenous dummy or binary variable (*seals*):

$$caries = l\ (\alpha_{11}\, sealants + x_{11}\, \beta_{11} + \varepsilon_{11} > 0) \qquad (8)$$

[21] The reduced form of a model is one in which the endogenous variables are expressed as functions of the exogenous variables.

$$sealants = l\,(\qquad x_{12}\,\beta_{12} + \varepsilon_{12} > 0) \tag{9}$$

$$(\varepsilon_{11}, \varepsilon_{12} \mid x_{11},\; x_{12}) \sim N\,(0{,}0{,}1{,}1, \rho)$$

where $l(..)$ is the indicator function that takes the value of 1 if the statement in the parenthesis is true and zero otherwise. α and β are regression coefficients and N(..,..,ρ) indicate standard bivariate normal distribution with correlation coefficients ρ. When ρ is zero the model for caries will be a standard probit. In describing the advantages of using multivariate probit models over log-linear models Arendt and Holm (2006) state that "[log linear model] only has one parameter describing the relation between y1 and y2 in contrast to the multivariate probit model, which has two types of relations, structural ($\alpha \neq 0$) and spurious ($\rho \neq 0$), and therefore allows for causal interpretations."

When the endogeneity problem is further complicated by adding another binary endogenous variable to the equation, i.e., dental visit frequency, multivariate probit models appear to be even more useful. The multivariate probit model will then have 3 equations, one structural equation and two reduced form equations,[22]

$$caries = l_1\,(\alpha_{21}\, seals + \alpha_{22}\, dental\ visit\ frequency + x_{21}\,\beta_{21} + \varepsilon_{21} > 0) \tag{10}$$

$$sealants = l_2\,(\qquad x_{22}\,\beta_{22} + \varepsilon_{22} > 0) \tag{11}$$

$$dental\ visit\ frequency = l_3\,(\qquad x_{23}\,\beta_{23} + \varepsilon_{23} > 0) \tag{12}$$

$$(\varepsilon_{21}, \varepsilon_{22}, \varepsilon_{23} \mid x_{21},\; x_{22}, x_{23}) \sim N\,(0{,}0,\ 0{,}1,\ 1{,}1, \rho_{212}, \rho_{213}, \rho_{221}, \rho_{223}, \rho_{231}, \rho_{232})$$

[22] An example of such modeling can be seen in Arendt and Holm 2006.

The likelihood function in this case contains multivariate joint probabilities. The GHK simulated maximum likelihood estimator is used to estimate these joint probabilities and test whether the estimates will be biased and inconsistent if a univariate probit equation was used instead of the multivariate probit model.

We know that in the presence of endogeneity maximum likelihood estimators are biased and inconsistent. It is therefore important to test for endogeneity in econometric models. When dichotomous variables are involved as the outcome and explanatory variables, the estimation can be done using probit models. In case there is no correlation between the error term ε_i of the equations used to perform a multivariate analysis, the hypothesis that the explanatory variables are exogenous cannot be rejected. In such situations a univariate model can be used for estimation without the obvious threat of unbiased and inconsistent estimators.

Monfardini and Radice (2006) tackle the complex issue of reliable testing for the exogeneity hypothesis in multivariate probit models by comparing different exogeneity test statistics. They examine four such tests: Lagrange Mulitplier, Conditional Moment Tests, Likelihood Ratio and Wald test. The exogeneity condition in the case of multivariate probit models is stated in terms of the correlation coefficient, *rho* or ρ, which can be explained as a correlation between the unobservable explanatory variables of the different equations in the multivariate model. In the bivariate form, when ρ is zero, it means that the outcome variable in the first equation is uncorrelated with the error term of the second equation of the model. However, if ρ is not zero, the outcome variable and error term of the other equation is correlated and therefore endogenous.

This can be explained econometrically as:

$$y^*_{1i} = x_{1i}\ \beta_1 + \varepsilon_{1i} \tag{13}$$

$$y^*_{2i} = x_{2i}\ \beta_2 + \varepsilon_{2i} = \delta_1\, y_{1i} + \delta_2\, z_{2i} + \varepsilon_{2i} \tag{14}$$

where i is the number of observations and ε is the random error term with mean zero and assumed to be independently and identically distributed as bivariate normal. x_{1i} and z_{2i} are vectors of exogenous variables.

Both y^*_{1i} and y^*_{2i} are latent variables and y_{1i} and y_{2i} are observed binary variables, such that

$y_i = 1$ if $y^* > 0$

$y_i = 0$, otherwise

If,

$H_0 : \rho = 0$

and,

$H_1 : \rho \neq 0$

the null hypothesis says that there is no correlation and hence we cannot reject that the variables are exogenous.

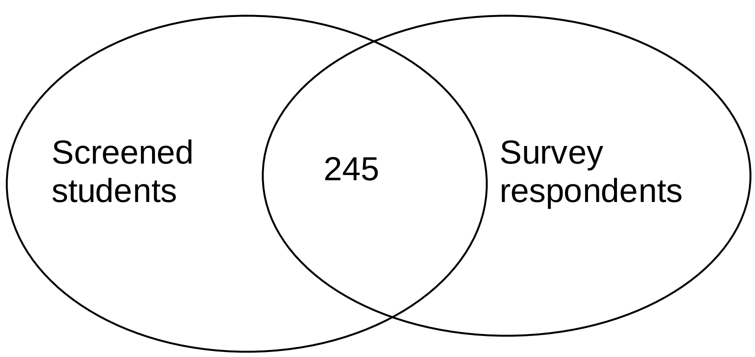
Monfardini and Radice (2006) use simulation set-up to obtain maximum likelihood estimates of bivariate probit models using the four tests for exogeneity mentioned above. The authors find that Likelihood Ratio test systematically "outperforms the other tests for all values of N and different nominal levels." They recommend likelihood ratio test for exogeneity hypothesis in bivariate and multivariate probit models. We would therefore use the likelihood ratio test to examine whether the variables that we suspect as endogenous are in fact endogenous or not.

5.2.3 Observations Regarding Survey Data

In using primary sources of data we had to contend with some limitations. First, we do not have clinical profile and socioeconomic factors from exactly the same time period. There is at least a two-year gap between the time of dental examinations and the survey responses from parents. Although we are able to match records from the examination and survey data using students' names and date of birth, we still have to assume that the socioeconomic and demographic factors do not change in this time period. Further, we assume that there is no change in the habits or preferences of the population regarding oral health care. We also assume that the information provided by parents through the survey questionnaires is accurate and reflects actual conditions to the best of their knowledge.

We therefore, end up with data from survey of parents of students currently enrolled from pre-K to grade 12. About a third of the records from the survey data were matched with the examination data from two years ago (Figure 5.1).

FIGURE 5.1: Matching data from two sources



Due to a time lag, there is a concern of any systematic selection bias between the students who went through the examination and those who completed the survey later. We checked this in two ways. First, we compared the dental characteristics, i.e. rate of dental caries and dental sealants between the original cohort examined two years ago by the teledentistry project and the matched sample. As shown in Table 5.1 the dental caries and sealant rates (47% and 20% respectively) were slightly higher in the dental examination cohort than in the matched sample (43% and 19% respectively) but not very different. We also found that the number of caries per child were very similar (3.6 caries per child in the matched sample versus 3.5 in the screened sample).

TABLE 5.1: Testing representativeness of matched data and screening data

	Matched data		**Screening data**
Observations	245		1186
Rate of dental caries	43%		47%
Rate of dental sealants	19%		20%
Caries per child	3.6		3.5

Second, we test the representativeness of the matched database (n=245) with the survey data (n=760). We do so by using two variables from the two sets of data and use chi-squared test to check for difference between the two (Table 5.2). We choose household income and parent's education as the two key variables on which to test the difference between the two and find no statistically significant difference. The only variable in which there was a difference between the two data sets was that of percentage of children who had stayed in Willacy County for longer than 5 years. That percentage was about 87% in the matched sample and 77% in the survey data. Since we were matching the survey data with examination data from two years ago, there was a likely bias towards those who have stayed in the county longer. However, as long as the selection bias is not on the basis of the outcome variable, our estimation results should not be biased by the difference in one right-hand-side variable, stay in Willacy county in this case. Other than that we found very similar distributions on all variables related to health and dental insurance, race, income, employment, and education. We can thus reasonably conclude that the matched sample is unbiased sample from the students who completed the written survey.

TABLE 5.2: Testing representativeness of matched data and survey data

	Matched data		**Survey data**
Observations	245		760
Household income			
income < $10,000	29.60%		29.62%
10,000 ≤ income < 25,000	35.87%		35.78%
25,000 ≤ income < 50,000	25.56%		24.78%
income ≥ $50,000	08.97%		09.82%
Pearson chi2	**0.567**		**Pr = 0.904**
Parent's education			
none	03.33%		04.49%
1-8th	20.00%		17.82%

high school	50.00%		48.98%
2-yr college	17.50%		18.10%
> 4-yr college	06.67%		07.35%
postgraduate	02.50%		03.27%
Pearson chi2	**2.696**		**Pr = 0.747**

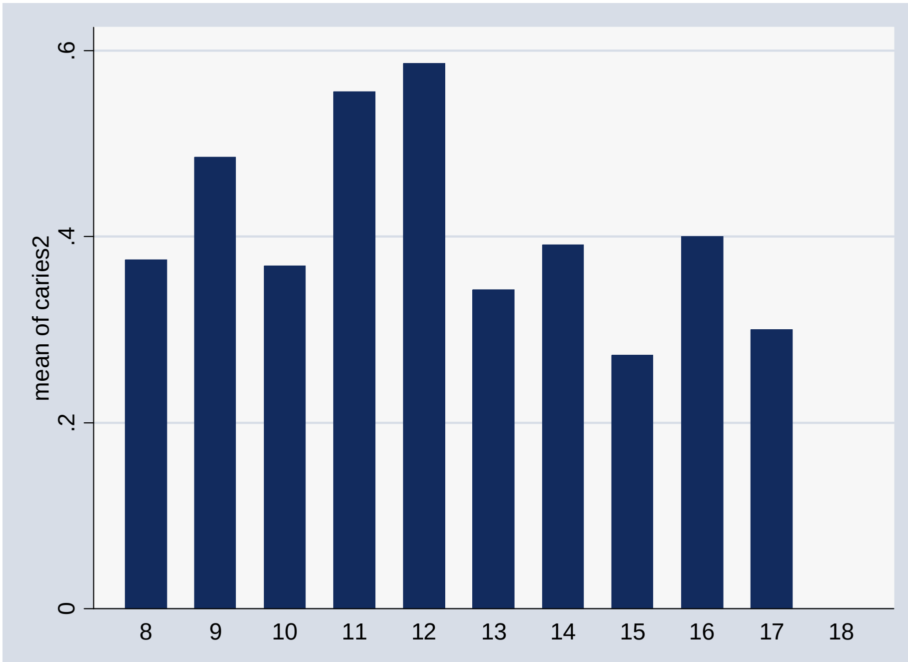
5.3 DESCRIPTIVE STATISTICS

5.3.1 Outcome Variable

Our main outcome variable is *caries2*, which indicates whether a student has dental caries in any of the teeth. This variable is derived from the examination data that indicate whether each tooth has dental caries or not. Caries incidence has been consistently used as a measure of oral health in various studies (Selwitz 2007).

In our sample, there are more cases of students who had no detectable caries (58%). The graph in Figure 5.2 reports the mean distribution of caries for different age groups and shows a higher incidence of caries in younger ages than in those over 12 years of age. The highest incidence of dental caries in our data is found in 11- and 12-year-olds.

FIGURE 5.2: Mean of dental caries with age in years



student's age

5.3.2 Policy Variable

The Task Force on Community Preventive Services (Truman2002) found strong evidence of the efficacy of school-sealant delivery programs in prevention of dental caries. However, the Centers for Disease Control and Prevention issued a report recently that showed that only a third (32%) of children 6- to 19-years-old had ever received dental sealants nationally (CDC, 2005). Application of sealants is therefore a measure that varies in the population nationally and which can have significant impact on the prevention of dental caries. Hispanics are reported to have even lower rates of dental sealants than whites (Flores 2002). Since dental sealants are almost always applied by a dental health professional as part of preventive dental care, we consider the presence of dental sealants as an evidence of past preventive care. It is also unlikely that a child may have a preventive visit without any sealant application because the clinical guidelines from the American Academy of Pediatric Dentistry clearly recommend sealant application in children and adolescents (AAPD 2003). Based on systematic reviews, dental sealants have also been accepted as effective prevention against caries. Therefore, from a policy perspective increasing dental sealant application in children is likely to decrease the probability of dental caries. We therefore choose application of sealants as our key policy variable to study the impact of school-based preventive care programs on dental caries. We obtain this information from the screening examinations.

While we have data on the application of sealants on each tooth, it is noteworthy that sealant application is mainly meant for molars. The pits and fissures which occur on the chewing surfaces of teeth make their surfaces susceptible to bacterial infections. Most dental caries in children and adolescents take place on these pit and fissure surfaces (Selwitz 2007; Ripa 1993). Dental sealants fill in these pits and fissures thus preventing bacterial growth and caries.

Since our unit of analysis is the individual, we use sealant application as a binary variable, *seals*, the absence of which indicates that no sealant has been applied and no prevention services received. This approach is often used in economic studies related to sealants where socioeconomic factors are important for the study (Griffin 2002).We check this assumption by cross tabulating application of sealants with last dental visit information (Table 5.3). We find that someone who had never had a dental visit, did not have a sealant application as well; thus, confirming our assumption that sealant application only occurs during a dental visit and is therefore a good proxy for preventive visit to a dentist.

TABLE 5.3: Cross tabulation of sealants and last dental visit

	Last dental visit			
Any sealant	< 1 year	>1 year	Never	Total
No	122	38	8	168
Yes	32	9	0	41
Total	154	47	8	209

Overall in our sample about 44% children have caries. This compares to the national average where NHANES data reported 42 percent 6- t o 19-year-olds have caries in their permanent teeth (CDC 2005). However, the prevalence of dental sealants in our sample was only 19%, which is only 60% of the national average of 32% for children and adolescents aged 6-19 years (CDC 2005). As seen in Table 5.4, almost half (49%) of the students with no sealant had caries, while only 19% of those with sealants had any caries. In other words, less than 10% of those with a sealant had any caries in their teeth. We found a difference at the 95% significance level in occurrence of caries between those with sealants and those without ($p < 0.0002$). This protective effect of sealants is not specifically measuring the effect on the particular tooth on which the sealant had been applied. Instead, it is just measuring the effect of a preventive visit, as shown by any sealant on any tooth, on the prevention of *any* caries on *any* tooth in a student. It is therefore reasonable to assume that the actual effect of sealant on preventing caries in the tooth to which it is applied will be stronger than what is seen in our analysis.

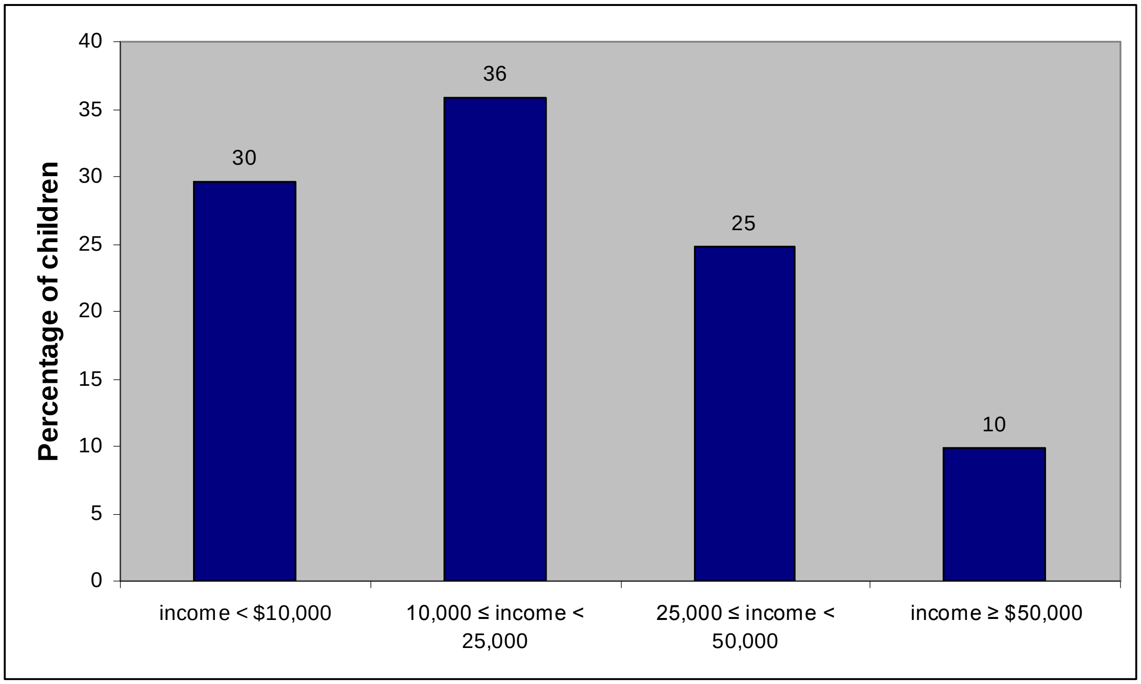
TABLE 5.4: Cross tabulation of dental caries and sealants

	Any sealant		
Any caries	No	Yes	Total
No	101 72.66 51.01	38 27.34 80.85	198 100 56.73
Yes	97 91.51 48.99	9 8.49 19.15	106 100 43.27
Total	198 80.82 100	47 19.18 100	245 100 100

5.3.3 Explanatory Variables

We expect socioeconomic and demographic factors to have an impact on dental caries incidence also. Poor children have twice as many dental caries as affluent children. Mexican-Americans are the most likely ethnic group to have never visited a dentist (13% versus 4% for anglos) (US DHHS 2000).Relative to more affluent segments of the population, low-income populations have a disproportionate level of dental disease. Minority populations also face high levels of dental disease (GAO 2000). Disparities in caries incidence are noticed across all age groups among racial/ethnic groups. Hispanic children are also reported to experience barriers to dental care greater than other ethnic groups (Flores 2002). We therefore use variables that reflect such differences in the sample, such as race, age, country of birth, and household income.

FIGURE 5.3: Annual household income



The median household income in Willacy County has been reported as $23,485 in 2003 by the Census Bureau. In our sample, majority of the student population comes from a family with annual household income below $25,000. When household income is treated as a binary variable, almost 66% of students come from a household with income below $25,000 – a level close to 100% of federal poverty guidelines[23] of $24,130 for a family of 5 and 125% of the poverty guidelines of $20,650 for a family of 4 in the 48 contiguous states of the United States (Federal Register 2007).[24]

[23] According to the Federal Register, Federal Poverty Guidelines 2007 calculate household income for a family of 5 to be $24,130 in the 48 contiguous states of the United States, $30,170 in Alaska, and $27,750 in Hawaii. http://aspe.hhs.gov/poverty/07poverty.shtml

[24] The number of students from low-income household in our sample is consistent with the 65% students in the 760 respondents to our survey in the school district.

TABLE 5.5: Descriptive statistics for variables in the dataset

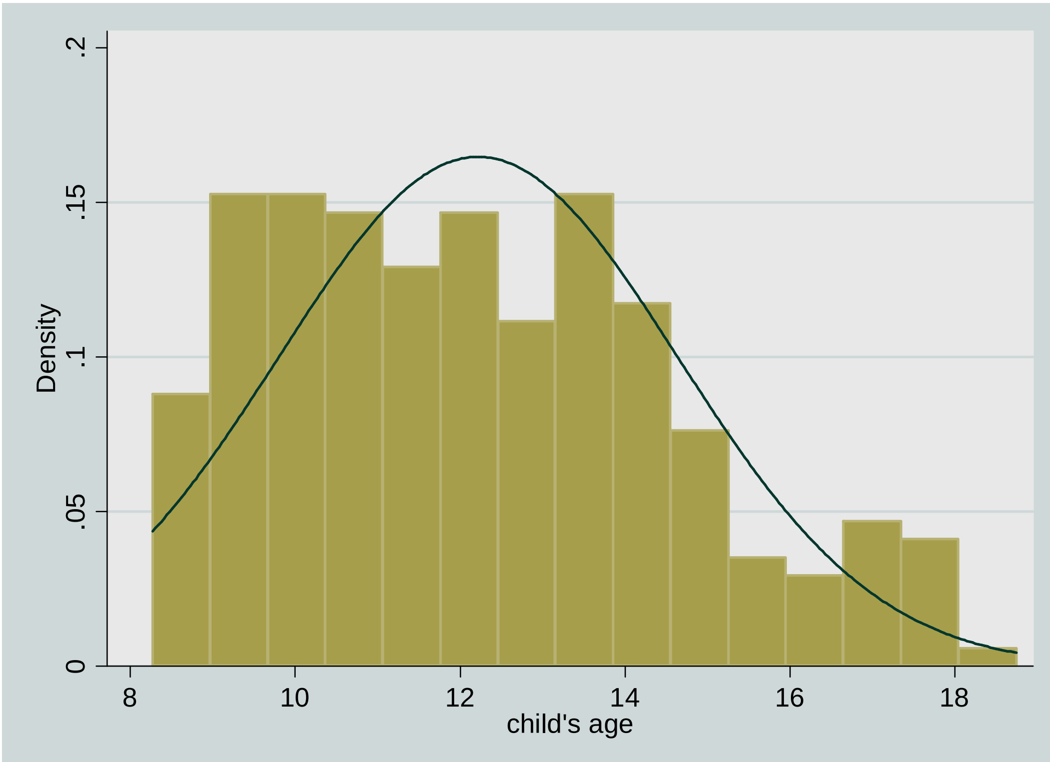
Variable	Mean	Std Deviation	Min	Max
Any caries (yes=1)	0.433	0.497	0	1
Any sealants (yes=1)	0.192	0.395	0	1
Age	12.218	2.421	8.271	18.741
Sex (Male=1)	0.445	0.498	0	1
Race (Non Hispanic=1)	0.025	0.157	0	1
Parent's education (<HS=0, HS=1, >HS=2)	1.009	0.699	0	2
Annual household income >$25k (yes=1)	0.314	0.465	0	1
Parent's dental insurance (yes=1)	0.202	0.402	0	1
Parent's health insurance (yes=1)	0.401	0.491	0	1
Child's dental insurance (yes=1)	0.410	0.493	0	1
Child's health insurance (yes=1)	0.624	0.485	0	1
Parent's crossing border for dental (yes=1)	0.279	0.449	0	1
Child's crossing border for dental (yes=1)	0.091	0.288	0	1
Stay in Willacy County (>5 years=1)	0.870	0.337	0	1
Child's country of birth (outside USA=1)	0.037	0.190	0	1
Parent's country of birth (outside USA=1)	0.209	0.408	0	1
Language spoken at home (English=1)	0.904	0.295	0	1
Knowledge of Medicaid eligibility of child (yes=1)	0.791	0.499	0	1
Knowledge of teledentistry project at school (yes=1)	0.354	0.479	0	1

The distribution of variables in the sample varies between some whose mean values are fairly close to 0.5 and those whose means are close to one extreme. From

Table 5.5 we can see that caries occurrence, sex, parent's education, household income,[25] parent's insurance status, and knowledge of teledentistry project are fairly evenly distributed among the sample. The means of the rest of the variables are not as evenly distributed and are closer to either 0 or the maximum of the categorical values. Sealants, language spoken at home, child's country of birth, crossing the border for health or dental reasons, and race are variables that fall into such a category. For instance, the mean value of the variable, *seals*, show that most students in the sample had no sealants (mean=0.19). The age variable, *c_age*, is a continuous variable. Figure 5.4 shows the age distribution in our sample. The mean age of the sample is just over 12 years which means that at the time of dental examination the mean of the same cohort would be just over 10 years. Most children under 10 years have primary teeth. By the time they grow older than 10 years they have lost most of their temporary teeth. Hence, the mean age in our sample is likely to give a fairly even spread of children with temporary and permanent teeth.

[25] See Appendix 5.A for explanation of the transformation of this variable.

FIGURE 5.4: Age distribution in years

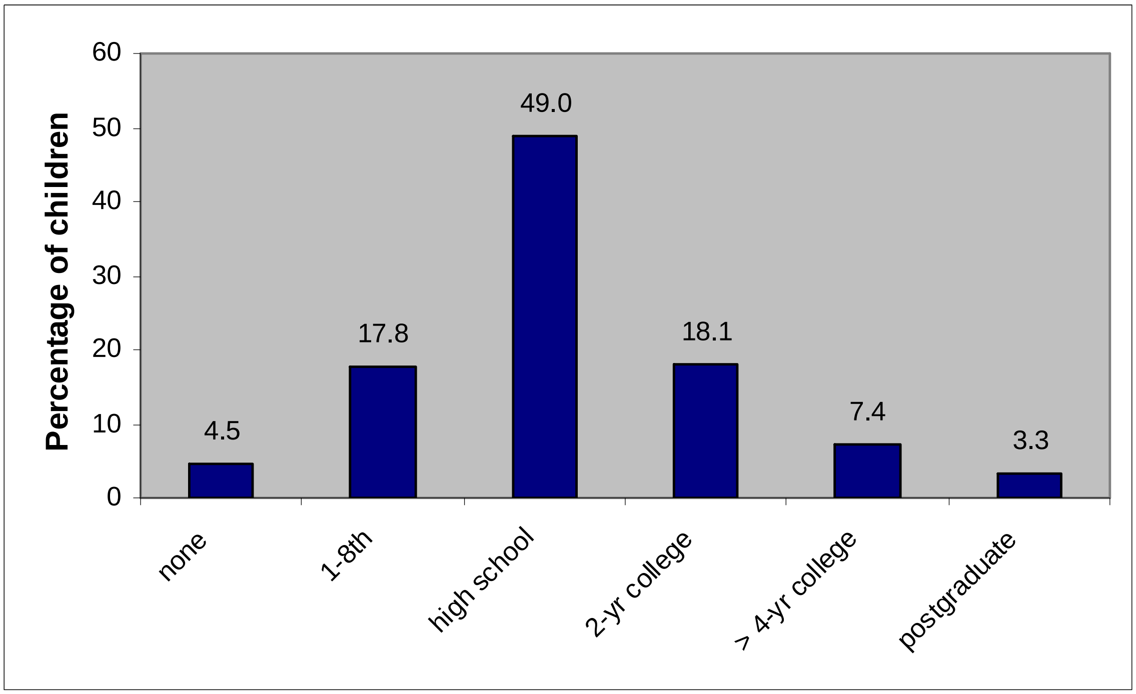


The race of almost all the students (97.5%) is Hispanic and so the mean for that variable is closer to 0, which is the value for Hispanic students. An analysis based on race differences in our sample is therefore unlikely to show significant or meaningful differences, since white, black and other races are not present in any significant number in the sample.

The distribution of parent's education (Figure 5.5) has a mean value that is close to high school education. Half (120/240=50%) of the parents have a high school diploma and another 25% have college or postgraduate degrees. This is slightly higher than the 61% Hispanic parents who were reported to have at least high school diploma in the

National Health Interview Survey (Flores 1999). Some surveys (8/240) were also filled in by parents who had no formal education.

FIGURE 5.5: Parent's education



We discuss the issue of dental utilization in detail in the next chapter. We, therefore, do not comment on the findings about dental utilization in our data here. To some extent last dental visit may also be captured by our policy variable, *seals*, which cannot be present in the data unless a dental visit has taken place. We do use this variable later in our analysis to make sure that the specification of our model is empirically sound in the presence of two variables, *seals* and *dentfreq2*, with potential endogeneity.

5.3.4 Caries and No-Caries Group Differences

When we examine the variation in occurrence of caries in the sample with sociodemographic factors, household income ($p<0.05$) appears the only socioeconomic variable in our dataset that has a significant difference between those with caries and without caries (Table 5.6). Surprisingly, parent's education does not have a significant difference between those with caries and without caries. This finding is in contrast to other studies that show parent's education to have a significant effect on occurrence of caries in children (Harris 2004, Eldstein 2002). We explore this anomaly in more detail later in our analysis.

Parents with health insurance ($p=0.0101$), and dental insurance ($p=0.0099$) show a significant difference between the two groups with and without caries. Interestingly, child's health insurance ($p=0.0469$) showed a significant difference between those with caries and without caries but child's dental insurance ($p=0.1277$) did not show a significant difference between the two groups. Such a finding may point to the possibility of either limited utilization among those children with dental insurance or lack of preventive care even in those with dental insurance. We also find variables related to parent's crossing the border for medical care ($p=0.0180$), and parent's crossing the border for dental care ($p=0.0825$) to have significant differences between those with caries and without. This is most likely an indicator of parent's awareness about dental and health care than actual provision of services across border. The reason we make that observation is because crossing the border for dental or health care of children does not seem to have any significant difference between those with or without caries.

TABLE 5.6: Group differences in means between those with and without dental caries

Variable	With Caries [*Std Dev*]	No caries [*Std Dev*]	P-value
Any sealants	.085*** *[.280]*	.273*** *[.447]*	0.000
Student's age	12.379 *[2.565]*	12.003 *[2.210]*	0.231
Sex	.406 *[.493]*	.475 *[.501]*	0.282
Parent's education	.99 *[.674]*	1.022 *[.720]*	0.727
Household income	.245** *[.432]*	.367** *[.484]*	0.042
Parent's dental insurance	.125*** *[.332]*	.259 *[.440]*	0.0099
Parent's health insurance	.308** *[.464]*	.471** *[.501]*	0.010
Child's dental insurance	.351 *[.480]*	.453 *[.450]*	0.128
Child's health insurance	.548 *[.468]*	.680 *[.468]*	0.047
Parent crossing border for dental	.340* *[.476]*	.234 *[.425]*	0.082
Child crossing border for dental	.076 *[.267]*	.101 *[.302]*	0.530
Stay in Willacy	.846 *[.363]*	.890 *[.315]*	0.332
Transport for dental visit	.074 *[.264]*	.063 *[.244]*	0.766
Child's birth country	.05 *[.219]*	.028 *[.166]*	0.437
Parent's birth country	.173 *[.380]*	.237 *[.427]*	0.230
Language spoken	.903 *[.298]*	.905 *[.294]*	0.955
Knowledge of Medicaid eligibility	.791 *[.409]*	.792 *[.408]*	0.987
Parent's work status	.455 *[.501]*	.455 *[.450]*	0.997
Knowledge of teledentistry project	.337 *[.475]*	.367 *[.484]*	0.641

5.3.5 Income Group Differences

Difference in household income is considered one of the most important factors in disparity of dental health status in the population (GAO 2000, Kenney 2005). We therefore look at differences in household income to see if there are systematic differences between those with low income and those with higher income (ie, >$25,000 annually). There are statistically significant differences in parent's education, parent's health insurance status, and language spoken at home between the two income groups (Table 5.7). The results show a statistically significant correlation between household income and caries occurrence. Those with low income have a higher caries incidence than those with higher income. The results also show that parent's education and whether they speak only Spanish at home is also significantly associated with household income. Those that speak Spanish only are more likely to be in the low household income group than those who speak English (with or without Spanish). Parent's education level is also associated with income, so that those with higher education are also the ones with higher income. As expected this difference is statistically highly significant.

TABLE 5.7: Mean value and standard deviation of variables by household income and p-values of group differences

Variable	Low-income [*Std Dev*]	High-income [*Std Dev*]	P-values
Any caries**	.476 *[.501]*	.338 *[.476]*	0.042
Any sealants	.202 *[.403]*	.167 *[.377]*	0.617
Sex (male)	0.441 *[.498]*	0.455 *[.501]*	0.839
Student's age	12.232 *[2.373]*	12.186 *[2.538]*	0.891
Race (nonHispanic)	.025 *[.156]*	.026 *[.161]*	0.941
Parent's education ***	.820 *[.688]*	1.425 *[.525]*	0.000
Parent's dental insurance**	.157 *[.365]*	.299 *[.461]*	0.010
Parent's health insurance***	.303 *[.461]*	.610 *[.491]*	0.000
Child's dental insurance	.422 *[.496]*	.387 *[.490]*	0.617
Child's health insurance***	.507 *[.451]*	.853 *[.356]*	0.000
Crossing border for parent's dental	.282 *[.198]*	.274 *[.449]*	0.902
Crossing border for child's dental***	.041 *[.198]*	.192 *[.396]*	0.000
Stay in Willacy >5yrs	.889 *[.315]*	.831 *[.377]*	0.216
Transport for dental visit**	0.097 *[0.298]*	0 *0*	0.014
Child's birth country* (not USA)	0.055 *[0.228]*	0 *0*	0.068
Parent's birth country** (not USA)	0.25 *[.434]*	.12 *[.327]*	0.022
Language spoken** (Not Spanish only)	0.871 *[.336]*	.974 *[.160]*	0.011
Knowledge of Medicaid eligibility*	.827 *[.379]*	.716 *[.454]*	0.067

Parent's work status	.487 *[.501]*	.389 *[.491]*	0.159

5.4 ESTIMATION RESULTS

5.4.1 Linear Probability Model

We start the estimation with a simple OLS regression model to examine the general direction of coefficients (Table 5.8). We use several possible combinations of variables that could be suspected to influence dental caries in children. Some of these variables cannot be ignored, irrespective their statistical significance in the empirical results. Others that were a borderline case, where the theoretical basis to include them was not strong, we relied on empirical results to see whether they should be included in a model to explain dental caries variation. We thus dropped variables related to Medicaid because the basis of eligibility is related to household income which is already a variable in our model. Similarly, parent's work status or the means of transportation they used for visiting the dentist were not included in the model.

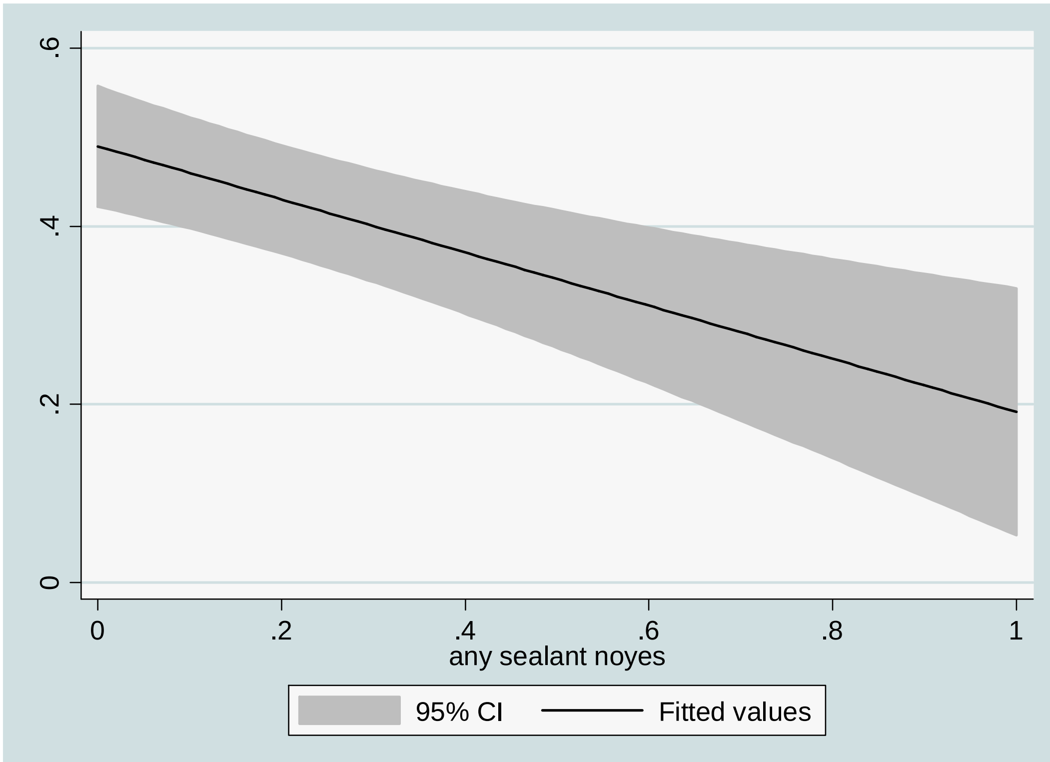
TABLE 5.8: Linear probability model results

Variables	Coef.	Std. Err.	P>|t|
any sealant	-.289	.090	.002
age	.007	.014	0.641
sex (male=1)	-.038	.066	0.568
parent education high school	.069	.091	0.448
parents education >high school	.116	.116	0.319

household income >$25,000	-.184	.077	0.018
parent's health insurance	-.153	.078	0.051
stay in Willacy >5yrs	-.087	.099	0.376
parent's birth country (not USA)	-.147	.096	0.124
language spoken (English)	-.074	.130	0.570
_cons	.665	.229	0.004
Obs	220		
Prob > F	.001		

The mean of the response variable, *caries2*, is close to 0.43. A linear regression should be able to give us a good idea of the effect of regressors on the response variable. The OLS shows that those who have a sealant are less likely to have dental caries. The coefficient of the sealant variable indicates slightly less than 30% less likelihood of dental caries in those with a sealant. The results also show that sealants are by far the most important factor in the model to affect dental caries in children. Figure 5.6 shows a linear regression line between dental caries and sealant with a 95% confidence interval band.

FIGURE 5.6: Linear regression line with 95% confidence bands for the conditional mean between dental caries and sealant



The regression results in Table 5.8 show that age has a very small impact on dental caries, although it is a positive relationship, as would be accepted in this case. Sex of the children and the education attainment of their parents do not have statistically significant effect on caries. The household income has a significant effect so that as income increases the chances of getting caries decreases. Parent's health insurance also seems to have a protective effect on caries.

We use Ramsey's omitted-variable regression specification error test (RESET) to test for misspecification of the functional form.[26] According to Baum (2006) the test runs an augmented regression that includes the original regressors, powers of the predicted

[26] implemented by Stata's commands: `estat ovtest`

values from the original regression and powers of the original regressors. The null hypothesis is of no omitted variables so in a misspecified model the null hypothesis will be rejected. Ramsey's test of our model does not reject the null hypothesis (Prob > F = 0.983), thus not ruling out the hypothesis that there is no misspecification of the functional form.

5.4.2 Heteroskedasticity Concerns

Cross-sectional data, like ours, often suffer from heteroskedasticity (Baum 2006, p.143). This means that the disturbance term's variance may be related to the value of the dependent variable. We run post-estimation tests and find that we reject the hypothesis of homoskedasticity in the model using Pagan-Hall test (Baum 2002)[27] which is the equivalent of Breusch-Pagan test for OLS regression. The econometric remedy to heteroskedasticity is to run robust regression model to improve the estimates (Woolridge 2002, p.57). We run the robust regression model to make the estimation more efficient and report results of robust regression in the subsequent tables in this chapter.

5.4.3 Endogeneity and Orthogonality of Variables in Linear Probability Models

A key concern with our model specification for dental caries in children is the possible endogeneity in the model. Endogeneity refers to the simultaneous determination of dependent (or response) variable and regressors. This may occur when one of the regressors has a two-way relationship with the dependent variable which means that while the response variable is affected by an explanatory variable, the explanatory

[27] Breusch-Pagan test is conducted for instrumental variables estimation in Stata using the ivhettest command (Schaffer 2002 IVHETTEST: Stata module to perform Pagan-Hall and related heteroskedasticity tests after IV http://econpapers.repec.org/software/bocbocode/s428801.htm)

variable itself is also affected by the dependent variable (Baum 2006). It may also occur as a result of omitted variables or measurement errors as discussed earlier in the chapter (Wooldridge 2002).

In our model specification, sealant application is hypothesized to affect dental caries incidence but theoretically, sealant application itself may also be the result of a visit to the doctor following dental caries. Therefore the variable measuring sealant application in children is a candidate for being an endogenous variable in this model.[28] The recommended solution to endogeneity in microeconomic models is to use instrumental-variables estimator (Baum 2006, p.185). We test the endogeneity by using instrumental-variables estimation in the linear model first.[29] The variables selected as instruments have to be exogenous to the model so that they are likely to affect sealant application but do not have an affect on the dependent variable. We choose variables such as parents' crossing the border for medicines and their mode of transportation to the dentist as instrumental variables (also called excluded instruments). These factors may theoretically affect someone getting sealant application for their kids but are not likely to affect whether their children get caries or not.

[28] The frequency of dental visits is another candidate that may be an endogenous variable in the model of dental caries. We discuss dental frequency later in the chapter.

[29] by using ivreg2 command, a Stata routine developed by Baum, Schaffer, and Stiller (2003) IVREG2: Stata module for extended instrumental variables/2SLS and GMM estimation http://ideas.repec.org/c/boc/bocode/s425401.html

TABLE 5.9: Instrumental variable regression

variables	Coef.	Std. Err.	P>|t|
any sealant	-.234	.106	.028
age	.028	.018	.129
sex (male=1)	-.064	.079	.414
parent education high school	.066	.112	.553
parents education >high school	.062	.136	.648
household income >$25,000	-.162	.096	.092
parent's health insurance	-.178	.096	.065
stay in Willacy >5yrs	-.189	.141	.182
parent's birth country (not USA)	-.184	.106	.085
language spoken (English)	-.086	.179	.632
_cons	.520	.296	.079
Obs	148		
Prob > F	.014		
Instruments tested: *seals*			
Hansen J Statistic	7.358		Chi-sq (5) P-value = 0.195
C statistic (orthogonality of suspect instruments)	0.068		Chi-sq (1) P-value = 0.794

Results of the regression using instrumental variable shows that sealants, household income, parent's country of birth and parent's health insurance status have significant effect on dental caries (Table 5.9). The negative coefficient on all these variables shows that presence of sealant, higher household income, parents having health insurance and parents being born outside the US all have some protective effect on dental caries in children.

We test the variable for sealant application for being endogenous (Table 5.9).[30] The null hypothesis for the orthogonality test is that the specified endogenous regressor, i.e. sealant, should be treated as exogenous. The test statistic, called C statistics or difference-in-Sargan statistic (Baum 2006) is distributed as chi-squared with degrees of freedom equal to the number of regressors tested. [31] In our model the null hypothesis cannot be rejected (P=0.7935) when we test the variable for sealants as an exogenous variable. This shows that we cannot reject the hypothesis that the variable for sealants is an exogenous variable in this model.

Then we perform another test for endogeneity based on Hansen J statistic. According to Hayashi (2000, p. 233-34) this endogeneity test statistic is similar to a Hausman test statistic. The test is used to find out if any of the regressors are endogenous with the dependent variable and the null hypothesis is that there is no endogeneity. When the variable regarding sealants is tested, our estimation shows that the null hypothesis of no endogeneity cannot be rejected (P=0.1530). Based on the C-Statistic and Hansen J Statistics, we can state empirically that we cannot reject sealants not to be endogenous in the dental caries model or in other words, cannot reject exogeneity of sealants.

5.4.4 Endogeneity and Identification Concerns in Multivariate Probit Models

The above testing is the result of postestimation of a linear probability model. As explained in the section on our estimation model earlier in this chapter, linear probability models may not be the most suitable methodology for estimation of our model. Our estimation methodology has to take into account the binary nature of our response and policy variables. In addition, theoretically we can suspect not only sealant application but

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[30] using `orthog` and `endog` option in `ivreg2`

[31] implemented by a user developed routine in Stata: `ivreg2`

also dental visit frequency to be endogenous in the model for dental caries. The time at which the last dental visit takes place in a child's history may affect the probability of dental caries. At the same time, the last dental visit or dental visit frequency itself may be the result of having dental caries and tooth ache. Although, as shown later, we do not find dental visit frequency to have any statistically significant effect on dental caries in our model, we must test the model specification for dental caries taking dental visit frequency into account. Our next step, therefore, is to make sure that we can get consistent and unbiased estimators using univariate probit model of dental caries.

The structural equation and reduced form equations we use for the multivariate models are given in Section 5.2 in equations (5), (6), and (7). We use GHK simulator, as described earlier in the chapter, and rely on the recommended Likelihood Ratio test to check if sealants and dental visit frequency are endogenous to the model of dental caries. For the multivariate probit estimation, we use the structural equation for caries and reduced form equations for the endogenous variables, sealants and dental visit frequency. This means that the structural equation will have all variables while reduced forms have all other exogenous variables plus any instruments. Since the variables in our model are mostly binary variables, the model may suffer from identification problem. Maddala (1983, p. 122) considers a probit model with two equations and an endogenous regressor to have identification problems. However, Wilde (2000) has shown that the parameters of a probit model with endogenous variables will be identified as long as the model has one continuously varying exogenous regressor. In our model the variable for age fulfills this criterion, hence solving the identification problem.

When we ran multivariate probit models, using a user-developed routine in Stata, the results for dental caries estimation (Table 5.10) have the same signs on the coefficients for sealants, household income, parent's health insurance and most other variables as seen in the linear probability model in Table 5.7. The LR test (P > 0.8085), which is recommended for testing endogeneity in multivariate probit models, shows that we cannot reject the null hypothesis that both sealants and dental visit frequency variables are exogenous to the model (Monfardini 2006). The maximum simulated likelihood estimator is consistent as the number of observations and the number of draws tend to infinity and is asymptotically equivalent to the true maximum likelihood estimator as the ratio of the square root of the sample size to the number of draws tends to zero. Given the relatively small size of our sample we sought to find convergence of our estimator at a relatively large number of draws.[32] We check the robustness of the results using different draws and different seed numbers but find consistent results of the LR test (Appendix 5.B).[33]

TABLE 5.10: Multivariate probit model results (draws#500, seed# 88)

variables	Coef.	Std. Err.	P>|t|
Any caries (yes=1)			
any sealant	-.902	1.014	.374
sex (male=1)	.252	.218	.247
age	.046	.083	.581
parent education high school	.246	.362	.497
parents education >high school	.388	.391	.321
household income >$25,000	-.628	.279	.024
parent's health insurance	-.161	.267	.546
dental frequency	-.650	1.390	.640
_cons	.085	1.235	.945

32 Stata help for mvprobit routine

33 The default number of draws for the procedure in Stata is five. We increase the number of draws to 500 while trying different seeds and by using *bfgs* (Broyden-Fletcher-Goldfarb-Shanno) and *nr* (Newton-Rhapson) techniques. The results of the LR test with different draws remain unchanged. Results of various draws and seed numbers can be seen in Appendix 5.B.

Any sealants (yes=1)			
sex	-.0317	.293	.884
age	.263	.064	.000
parent education high school	-.409	.400	.085
parents education >high school	-.185	.563	.135
household income >$25,000	-.720	.420	.374
parent's health insurance	.952	.370	.035
_cons	-5.109	1.182	.000
Dental frequency (high=1)			
sex	-.226	.268	.086
age	.038	.059	.194
parent education high school	-.729	.450	.105
parents education >high school	-.420	.569	.460
household income >$25,000	-.559	.329	.037
parent's health insurance	-.175	.334	.600
_cons	.540	.977	.580
Obs	190		
Prob > chi2	.005		
Likelihood ratio test of rho21 = rho31 = rho32 = 0			
Prob > chi2 = .7453			

More specifically, the null hypothesis states that the correlation coefficient between the different equations and error terms of the multivariate probit model, $\rho = 0$. A rejection of the null hypothesis would have indicated that there is endogeneity in the model. However, in our model we cannot reject the null hypothesis of exogeneity, thus allowing us to use the univariate probit model without serious concerns about consistency and bias in estimated parameters. Given these findings, we would prefer to use univariate probit models for our estimation because the univariate models require less numerically daunting techniques and are less data-intensive than multivariate probit models.[34]

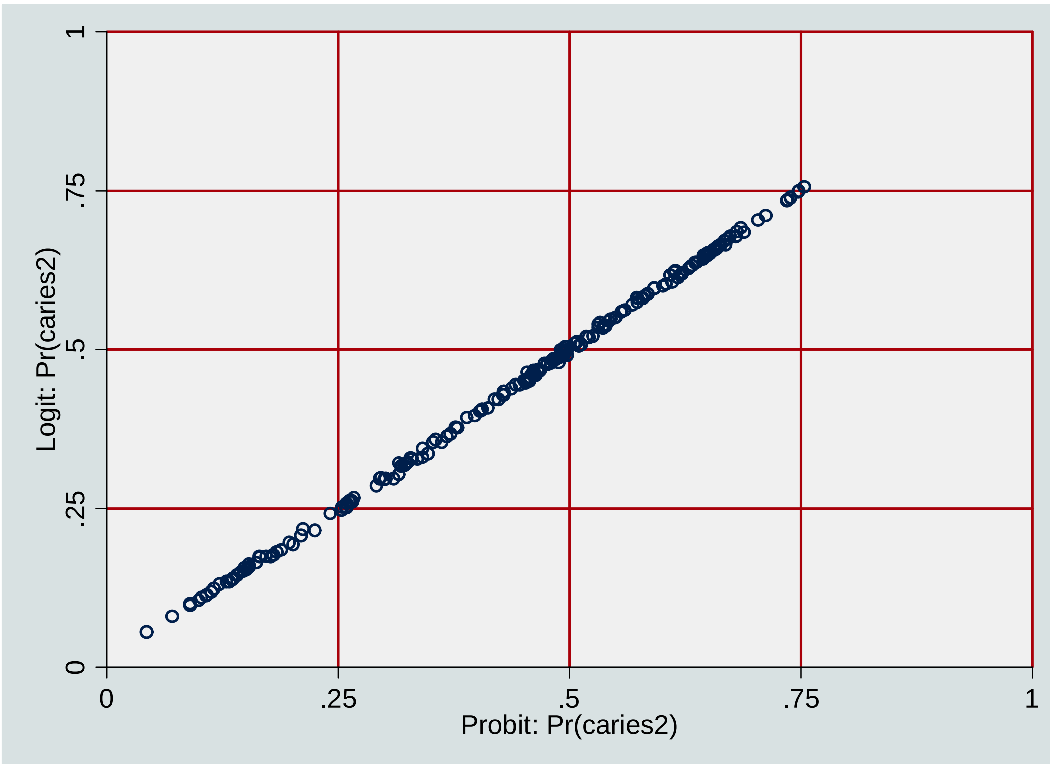
[34] Mutlivariate probit models also assume that the reduced form equations are correctly specified.

5.4.5 Univariate Probit Model Estimation

While probit regression gives coefficients which are not easily interpreted, their magnitude and sign give us some indication of the nature of the relationship between the dependent variables and explanatory variables. Since coefficients from binary regression models are hard to interpret without transformation, we use marginal coefficient effects or $d\Pr(y=1|x)/dx$[35] to measure change in the dependent variable for unit change in regressors. We can also get the marginal effects of these coefficients, Table 5.11 reports marginal coefficient estimates and standard errors for probit and logit models and compares it with an OLS regression. Because we have a dichotomous dependent variable, Model 2 and 3, run the same model using logit and probit models respectively. A comparison of the predicted values from logit and probit regressions when plotted on a graph in Figure 5.8 shows no difference between the two.

[35] `mfx` command for logit and `dprobit` for probit models in Stata 9.0

FIGURE 5.7: Comparison probit and logit predicted values



We use demographic, socioeconomic and health-related variables along with the policy variable, *seals*, to understand the variability in the dependent variable, *caries2*. The variables were selected based on theory. However, for those variables where theoretical evidence was mixed or not present, we tested their relevance to the model by using Wald test. A rejection of the Wald test shows that the variable does not have a significant contribution in explaining the variation in the outcome variable.

TABLE 5.11: Estimation results with marginal coefficients

Variables	OLS Regression Model 0	Logit Regression	Marginal Coefficients of Logit Regression Model 1	Probit Regression	Marginal Coefficients of Probit Regression Model 2	Probit Regression with Hispanic Only	Marginal Coefficients of Probit with Hispanic Only Model 3
any seal	-0.278	-1.419	-0.299	-.841	-.295	-.844	-.300
SE	*[0.086]****	*[0.464]****	[.077]	*.267****	*.078****	*.274****	*.082***
age	0.052	0.030	0.007	.015	.006	.015	.006
SE	*[0.084]*	*[0.064]*	[015]	*.039*	*.015*	*.040*	*.016*
sex (male=1)	-0.024	-0.096	-0.023	-.050	-.020	-.084	-.033
SE	*[0.065]*	*[0.296]*	[.072]	*.179*	*.070*	*.182*	*.071*
parent education high school	0.054	0.225	0.055	.147	.057	.193	.075
SE	*[0.091]*	*[0.403]*	[.098]	*.245*	*.096*	*.247*	*.097*
parents education >high school	0.094	0.394	0.097	.254	.100	.310	.123
SE	*[0.115]*	*[0. 486]*	[.120]	*.302*	*.120*	*.308*	*.122*
household income >$25,000	-0.159	-0.726	-.170	-.455	-.172	-.516	-.197
SE	*[0.076]***	*[0.336]***	[.075]	*.205***	*.075***	*.210***	*.077***
parent with health insurance	-0.162	-0.726	-0.172	-.447	-.171	-.432	-.167
SE	*[0.077]***	*[0.341]***	[.078]	*.2108***	*.077***	*.210***	*.079***
stay in county >5yrs	-0.046	-0.234	-0.053	-.141	-.056	-.245	-.097
SE	*[0.096]*	*[0.440]*	[.109]	*.266*	*.105*	*.271*	*.108*
parent's born outside USA	-0.145	-0.662	-0.153	-.412	-.155	-.430	-.163
SE	*[0.096]*	*[0.439]*	[.096]	*.264*	*.094*	*.265*	*.098*
language english	-0.09	-0.355	-0.088	-.223	-.088	-.212	-.084
SE	*[0.131]*	*[0.611]*	[.152]	*.366*	*.145*	*.368*	*.147*

Constant	0.676	0.588		.388		.502	
SE	*[0.163]****	*[0.986]*		*.608*		*.618*	
Observations	228	227		227	227	220	220
Pseudo R^2		0.094		.094		.101	
F-statistics	**.003**	**.005**		.002	.002	.001	.001
Obs. P					.4317		.4455
Pred. P					.4180		.4329

As 97.5% of our sample is Hispanic, we run a restricted model, Model 3, for students whose race is Hispanic.[36] Model 3 has slightly better explanatory power when restricted to Hispanic students in the sample as compared to Model 2. The coefficient for the policy variable is almost unchanged between the two models. The coefficients of all other variables also do not change their direction. The predicted mean of the dependent variable in our model is 0.435, compared to the observed mean of 0.448.

The models show that the presence of sealants at the time of the clinical examination has a positive impact on the absence of caries. The marginal effect of sealants in a probit model on dental caries is -0.300 ($P<0.001$) with a standard error 0.079. This coefficient shows that for the discrete change of the variable *seals* from 0 to 1, ie, if a student has a sealant, the probability that this student will have dental caries is decreased by 0.3. To calculate the likelihood of dental caries occurring when a child has had a sealant application versus the likelihood without any sealant we run a logistic regression and estimate the odds ratio (Table 5.12). The logistic regression shows that the odds ratio of having dental caries are 75% less (OR 0.24, SE 0.114) with a sealant or in

[36] According to Long and Freese (2006, Regression Models for Categorical Dependent Variables Using Stata) if the dependent variable does not vary within one of the categories of an independent variable, this problem of estimation should be resolved by taking out such cases from the estimation. p.192.

other words if a child has any sealant, the odds of the child having any caries are only a quarter of the odds of a child without any sealant having caries.[37]

TABLE 5.12: Odds ratio from logistic regression

variables	Odds Ratio	Std. Err.	P>|z|
any sealant	.241**	.114	.003
age	1.030	.068	0.650
sex (male=1)	.862	.258	0.619
parent education high school	1.352	.550	0.459
parents education >high school	1.617	.802	0.333
household income >$25,000	.437**	.150	0.016
parent's health insurance	.497**	.171	0.042
stay in Willacy >5yrs	.666	.296	0.361
parent's birth country (not USA)	.499	.221	0.116
language spoken (English)	.712	.440	0.582
Obs	220		
Prob > F	.004		

Table 5.12 also shows the highly statistically significant association between the outcome variable, *caries2*, and the policy variable, *seals*, remains consistent throughout different models. This confirms the hypothesis that preventive services, as measured by application of sealant on teeth of children, significantly reduce the occurrence of dental caries. The extent of the preventive effect of sealants in this underserved population is slightly higher than that found in a systematic review of available evidence (Truman 2002). Preventive care is relatively more effective in populations with high caries rates which can explain the slightly higher effect of sealants in our sample compared to the

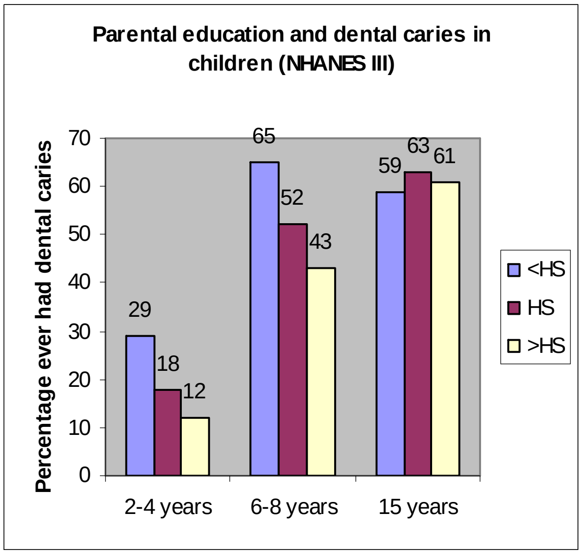
[37] Odds = Pr(caries) / Pr(no caries)

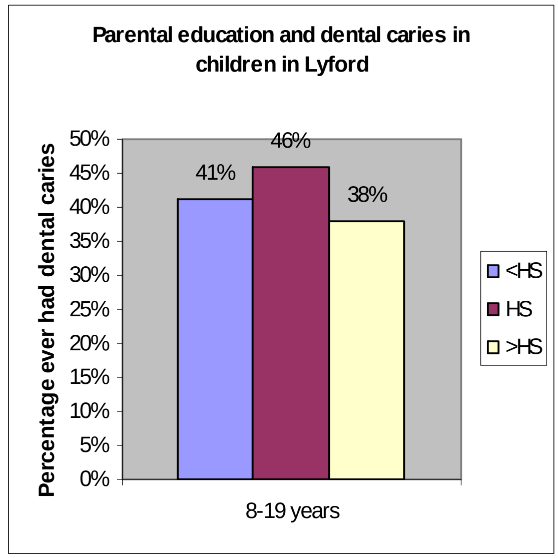
general population (USDHHS 2000). This result further emphasizes the need for preventive care in underserved populations, such as that in Willacy County.

5.4.5.1 Effect of Sociodemographic Variables

A somewhat surprising result from our data is that parent's educational level does not seem to have a significant impact on dental caries in their children. The coefficients for parent's education variable become slightly higher when a sensitivity analysis is conducted without variables such as language and country of birth of parents. However, this is in contrast to national survey data that show a correlation between low parental education and higher prevalence of dental caries in younger aged children (Eldestein 2002). When compared with the results from NHANES III our results, as shown in Figure 5.8, resemble more the distribution seen in older adolescents (15 year-old) at the national level where parental education does not correlate with dental caries in the same way as seen in younger ages.

FIGURE 5.8: Parental education and dental caries in children





It is possible that other variables in the model like household income and language are correlated with the differences in parent's education that show up in the national survey analysis based on simple correlations. However, when we drop these regressors from our model, education still does not become statistically significant. Another explanation of this result is the difference between traditional schooling and what has been termed as "dental IQ" (Moore 1978). Parents who have less schooling might not necessarily have a lower dental IQ. A better construct of the variable would be based on some sort of an evaluation of the dental IQ of parents, which would have allowed us to measure if parent's education about preventive dental care helps prevent caries in their children. There could also be certain cultural differences peculiar to our Hispanic sample. For instance, in interviewing community members in Lyford School

District we were informed that there are several efforts in the community to get together and be educated about diabetes or sexually transmitted infections. Such educational activities will not be reflected in the number of school years but definitely contribute to raising the dental IQ of the population.

Household income is strongly related to dental caries in our data and an increase in household income reduces the probability of having caries. The marginal effect of household income on caries is -0.195 ($p < 0.05$), thus a child from an average household in the high-income category has a 0.2 lower probability for caries than someone from the low-income household. Table 5.12 shows that in terms of odds ratio, the chances of having caries are 56% less in children from higher income households as compared to those from low income households. The $25,000 cut off in the household income was close to the federal poverty threshold of $23,400 for a family of five (*Federal Register* 2006, pp. 3848-3849). Wald test was used to make sure that combining separate categories of household income had no statistically significant difference (Appendix 5.A).

The significant effect of household income on dental caries in Hispanic populations supports similar results found in general populations in the United States (Mouradian 2000; Manski 2001). Poverty is the single most important indicator of disparities in dental care (Ryan 2003). However, the unique feature of our result is that the household income effect seems to be strong despite no significant effect of educational status of the parents. Most dental studies on caries and socioeconomic factors have found these to go together (Eldestein 2002). Our results therefore show that in such underserved Hispanic populations, family income level may explain a great deal more of the variation in dental caries than in the general population.

Parent’s health insurance status also affects the occurrence of caries in the model and this effect is statistically significant at the 95% level of confidence. Interestingly this effect is not seen when we used child’s health or dental insurance status. The marginal effect of parent’s health insurance on caries incidence is -0.172 ($p < 0.05$). This means that if the parents had health insurance, their children in our sample had about 0.17 less probability of having dental caries as compared to those children whose parents did not have health insurance.

It may be apparently puzzling that parent’s health insurance has a significant effect on dental caries in children even though child’s dental insurance does not. First of all, there is a difference between insurance (or coverage) and utilization (or access) in medical and dental care (Ryan 2003; Mouradian 2000). The impact of dental insurance on dental utilization is less apparent than in the case of medical insurance. Dental insurance is difficult to get on an individual basis and is usually so expensive for an individual that they are better off paying out-of-pocket for incident expenditures. This difficulty in getting dental insurance is partly due to the fact that dental care is much more predictable, so that patrons can plan to take insurance when expenditure is likely to increase and then drop out when those needs are met. Dental insurance coverage is therefore mostly offered only as part of a group plan so that risk is distributed over a larger number of individuals. Secondly, even when dental insurance is present the copay and deductibles are often higher than those for medical visits. The General Accounting Office reported that poor children who are eligible for Medicaid are less likely to receive dental care than children from middle- or high-income families with no dental coverage (GAO 2000). A possible explanation for the significant effect of parent’s health insurance on dental caries incidence in children is that those parents who value health care to the extent that they maintain their own health insurance also promote healthy dental behavior in their children.[38] This healthy behavior leads to fewer occurrences of caries in the children whose parents have health insurance and is more important than the children themselves having some coverage for dental visits.

Our model also includes other variables as proxies for environmental exposure and cultural/ethnic differences among the children. Those children whose families have lived in Willacy County (where Lyford School District is located) more than five years have a lower incidence of caries than those who have shorter duration of stay. We did not directly ask about migratory worker or new immigrant status because of the sensitivity of the information and hope that this phenomenon is captured in the variable about stay in Willacy. It is likely that those who have stayed at one place for more than five years have a steady source of income or employment and also are more aware of access points for getting preventive dental care for their children. For instance, children of migrant workers are more likely to have no preventive care and high rates of infectious diseases, and are at risk for nutritional disorders (McLaurin 1999; Flores 2002).

Whether parents of the children were born in the United States or abroad (mainly Mexico in our sample) also affects the probability of caries in children. Those children whose parents were born abroad had slightly less chances of caries than those whose parents were born in the US. This is not simply explained by differences in household income and therefore just having parents that were not born in the US seems to have a protective effect on the dental caries in their children.[39] Such a difference can be the result of genetic differences or simply differences in family traditions about the type of

[38] Most child dental insurance is likely to be public coverage while a lot of parental health insurance is private. This means that parents have to be aware of the importance of maintaining good health for them to spend on health coverage. This awareness will directly affect the behavior of their children and show up as decreased dental caries prevalence in their children. This goes back to the point about dental IQ.

[39] In our sample, almost 80% of parents were born in the US and 20% in Mexico. There was only 1 child whose parents were born outside these two countries. There is a difference in household income levels of parents born in the US (almost a third, 66/189, being in high income category) and those born in Mexico (less than a tenth, 9/50, in high income category)

nutrition or dental habits. Type of nutrition refers to mainly differences in dietary habits which have been shown in studies of other health problems that are seen mainly in Hispanic children (Felkner 2005). There is also literature that relates to acculturation and its effect on nutritional habits and chronic disease in immigrants. For instance Gordon-Larsen (2003) show that longer US-stay in Hispanic families is related to higher incidence of obesity in children. Similarly, Sun (1997) showed that dietary habits of native Chinese children were healthier than US-born Chinese-American children.

Finally, we compare those children who speak only Spanish in their homes with those that speak English (in addition to or without Spanish). There appears a decrease in caries occurrence in those who speak English at home compared to those who only speak Spanish at home. This finding may be an indicator of poor skills in English acting as a barrier to seeking preventive care. It could also be a proxy to a cultural difference between Spanish-only speakers and others. There is research that shows that healthcare seeking behavior may be affected by the language of the patients. There is also a dearth of Spanish-speaking health providers in the border areas of Texas (Warner 2003, TSCBH 2000) which may explain the effect of proficiency in English on preventive dental behavior.

The estimation results show no significant effect of age on dental caries. Age is a continuous variable in our equation and it is possible that due to the variation in milestones in different individuals our model is not able to capture a statistically significant effect of age. Because there are some studies that show age to have an effect on dental caries, we add a binary variable of age with 10 years as a threshold and run the model (results not reported here). The reason we choose 10 years as a cut off age because most children below 10 years have some temporary teeth while those above 10 years have mainly permanent teeth. However, we do not find any statistically significant effect of the binary age variable and it further diminishes the effect of the continuous age variable.

We run several different variations of Model 3 as sensitivity analysis (Table 5.13). For example, in Model 4 we drop education as a variable to check if its effect is being captured by another variable. No significant change is observed in the coefficients of other variables. We bring back parent's education in the Model 5 but drop language variable, parent's country of birth in Model 6 and stay in Willacy County in Model 7. No change in the direction of any of the coefficients is observed.

TABLE 5.13: Sensitivity Analysis using various probit models

	Probit Hispanic Only	**Marginal Coeff Probit Hispanic Only**	**Probit Hispanic Ony w/out education**	**Marginal Coeff Hispanic Only w/out education**	**Probit Hispanic Only w/out language**	**Marginal Coeff Hispanic Only w/out language**	**Probit Hispanic Only w/out parent's birth country**	**Marginal Coeff Hispanic Only w/out parent's birth country**	**Probit Hispanic Only w/out stay in county**	**Marginal Coeff Hispanic Only w/out stay in county**
Variable		Model 3		Model 4		Model 5		Model 6		Model 7
any seal	-.844	-.300	-.874	-.309	-.854	-.303	-.870	-.308	-.852	-.303
SE	*.274****	*.082***	*.272*	*.080***	*.274****	*.082****	*.273****	*.081***	*.272****	*.081***
age	.015	.006	.017	.007	.017	.007	.012	.005	.013	.005
SE	*.040*	*.016*	*.040*	*.016*	*.040*	*.016*	*.040*	*.016*	*.040*	*.016*
Male	-.084	-.033	-.072	-.028	-.092	-.036	-.121	-.048	-.099	-.039
SE	*.182*	*.071*	*.181*	*.071*	*.181*	*.071*	*.180*	*.071*	*.181*	*.071*
Parent education high school	.193	.075			.156	.061	.265	.104	.216	.085
SE	*.247*	*.097*			*.238*	*.093*	*.243*	*.095*	*.247*	*.096*
Parents education >high school	.310	.123			.278	.110	.395	.156	.331	.131
SE	*.308*	*.122*			*.302*	*.119*	*.304*	*.120*	*.305*	*.121*
Household income <$25,000	-.516	-.197	-.451	-.173	-.519	-.198	-.520	-.199	-.506	-.193
SE	*.210***	*.077***	*.202*	*.075***	*.210*	*.076***	*.210***	*.078***	*.208***	*.076***

parent with health insurance	-.432	-.167	-.372	-.144	-.360	-.168	-.388	-.150	-.417	-.161
SE	*.210***	*.079***	*.192*	*.073***	*.230*	*.079***	*.213**	*.081**	*.209***	*.079***
stay in county >5yrs	-.245	-.097	-.267	-.106	-.256		-.259	-.103		
SE	*.271*	*.108*	*.269*	*.107*	*.271*		*.271*	*.108*		
parent's born outside USA	-.430	-.163	-.479	-.181	-.315	-.138			-.438	-.166
SE	*.265*	*.098*	*.269*	*.093*	*.538*	*.085*			*.265**	*.096*
language english	-.212	-.084	-.141	-.056		-.101	.037	.015	-.233	-.092
SE	*.368*	*.147*	*.351*	*.140*		*.108*	*.314*	*.123*	*.369*	*.147*
Observations	220	220	220	220	220	220	220	220	220	220
Prob > F	.000		.000		.000		.002		.002	
Pseudo R^2	.100		.097		.099		.092		.092	

5.5 CONCLUSIONS

Our study suggests that application of sealants reduces the incidence of caries in school children. This decrease is significant and is observed in different variations of the econometric models that we used. We, therefore, confirm our hypothesis that preventive services, as measured by application of sealants in children, will reduce the occurrence of caries. We explored the possibility that presence of caries could also result in a visit to the dentist where preventive care in the form of application of sealants may occur. We test for a potential endogeneity problem in our model but our tests showed this not to be a problem.

The importance of other demographic and socioeconomic factors that may affect caries in children were also observed in our data. Household income, parent's country of birth, and parent's health insurance status were significantly associated with reduced caries incidence. The direction of the association for all the variables used in the model were as expected. Another interesting result was that children whose parents were born outside the US had fewer occurrences of caries than those whose parents were born in the US. The possible explanation of this difference may relate to nutritional habits and acculturation. The effect of parent's education did not come out as strong as we had expected based on earlier work using national survey data (Ersin 2006). It is possible that our measure of education that was based on the number of years of schooling was not accurate enough to capture differences in knowledge about dental health behavior among parents and adult caregivers in our sample.

Our data was collected from a school-based sealant program of teledentistry. Although we did not specifically study the effect of teledentistry on the delivery of services, we study the potential impact of sealants on caries. The argument we make is that such school-based sealant programs are very helpful in reducing the occurrence of caries in school children. In fact, the advantages of a school-based sealant program in reducing caries are beyond the protective effect of sealants in covering pits and fissures. All these benefits are hard to measure empirically given the limitations of our data but they ought to be considered from a policy perspective. For instance, school-based sealant programs can also help educate children about healthy dental habits thus performing a lifelong contribution to their health. Many dental diseases can be prevented by adoption of healthy habits and avoidance of sweets, sodas, and other foods that affect dentition. It has also been shown in studies that regular dental screening can help prevent most carious conditions and increases the impact of sealants (CDC 2005). Regular screening also helps in identifying and treating any early signs of periodontal diseases (infections or inflammation of gums) or oral cancers (Gooch 2002). School-based programs also save the cost and trouble of transportation of children to dental offices outside the school premises. Such transportation either involves parents taking time off their work or teachers chaperoning students to nearby clinics. The time required for such examinations is much more than that for providing the same services within the school environment. The old adage that prevention is better than cure applies to dental health as much as to any other field of medicine. Hispanic populations and low-income families, who have low dental utilization rates and a disproportionate burden of oral disease, can benefit greatly from school-based sealant programs.

Chapter 6: Dental Care Utilization among Underserved Populations

6.1 INTRODUCTION

As a preventable disease, dental caries can be significantly controlled at a population level by providing regular screening and preventive services to children from an early age. Such a policy will help in bringing up a generation with relatively few dental caries and other related diseases, thus reducing the economic and personal costs associated with the most common chronic disease of childhood in America. There are significant differences in the prevalence of dental caries depending on factors such as family income, race or ethnicity, geographical location, and other sociocultural factors (Selwitz 2007, US DHHS 2000). These differences not only influence the occurrence of the disease but also influence dental care sought by children belonging to different groups (Lewis 2007, Kenney 2005). National survey data show disparities in dental care utilization across the nation and understanding these disparities is an important piece of understanding the role of preventive care in reducing dental caries in underserved populations. Manski (2001) describes dental utilization studies as “an important tool for health policy decision-making (p.655).” Similarly, Macek (2002) states “Policymakers also use these [dental utilization] data to identify barriers to oral health care for specific population subgroups and to create programs that eliminate obstacles to oral health care.” This chapter examines the epidemiology of dental care utilization in children and adolescents in the United States and results from our data on factors that influence dental care utilization in children.

6.2 DENTAL CARE UTILIZATION

The terms dental visit frequency and dental care utilization are used synonymously in public health and oral health literature. The American Academy of Dental Pediatrics' clinical guidelines for periodic dental visits recommends a semi-annual visit for children and adolescents (AAPD 2005). Dental utilization is, therefore, usually measured in terms of last visit to the dentist or number of visits during the last one year (Newacheck 1999, Macek 2002, Vargas 2000). Watson (2001) describes utilization as a function of the patients or their families knowing how to use available resources effectively. Utilization may also be measured as proportion of people with at least one visit during the previous year. Manski et al (2001) use Medical Expenditure Panel Survey[40] (previously called National Medical Expenditure Survey) to measure utilization as a dental visit during the last one year. Kenney et al (2005) examine the National Survey of American Families and use the number of visits in the last 12 months to measure adequate dental care. The National Health Interview Survey (NHIS)[41] in 1993 also used number of visits in last 12 months to measure dental utilization (Macek 2002). Another national survey called the National Health and Nutrition Examination Survey (NHANES III),[42] however, collects information on utilization by inquiring about the time period since last visit to the dentist (Vargas 2000).[43] Fisher et al (2004) define their exposure variable as "dental service" which is measured as having a dental visit or not.

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[40] MEPS is a survey of families, individuals, medical providers, employers across the United States. It collects data on use, cost and payment sources. It has two major components: household and insurance. Other components include medical provider component and nursing home component. (www.meps.ahrq.gov)

[41] NHIS is a survey of the non-institutionalized civilian population conducted by National Center for Health Statistics and collects data on a broad set of health topics.

[42] NHANES is a nationally representative longitudinal survey of residents of the United States from age 2 months and above. NHANES III surveyed over 40,000 individuals. (http://www.cdc.gov/nchs/about/major/nhanes/nhanes2005-2006/nhanes05_06.htm)

[43] The question asked in NHANES III related to dental care: "How long ago was ______'s last visit to a dentist or dental hygienists?"

Macek et al (2002) compare utilization measures in three different national surveys, National Health Expenditure surveys (NMES, MEPS), NHANES, and National Health Interview Survey (NHIS). They find discrepancies in the estimates of utilization measured by these surveys. These differences are explained by varying time periods, lead-in statements, and format of questions. For instance, while MEPS and NHIS measure dental visit in the last 12 months, NHANES measures time period since last visit. As reported by Macek, NHIS 1993 produced an overall dental utilization estimate of 64% while NHANES III (1988-94) and MEPS (1996) produced estimates of 52% and 45%, respectively.

Most surveys use the last dental visit as a measure of dental visit frequency. Few surveys ask respondents to categorize their frequency of dental visits. Of the national surveys mentioned above, NHANES III asked questions regarding the frequency of dental visits. It classified dental visit frequency as regular use ("every year"), episodic use ("as needed") and no use ("never") (Vargas 2000).[44] Only "regular use" was considered adequate dental utilization under the existing guidelines and standards of dental practice. The difficulty with this measure of dental visit frequency is that it is self-reported and is unlikely to yield accurate information in populations that have inconsistent source of dental care. Vargas (2002) used NHANES 1988-94 to calculate preventive dental care among children and found only 37% of 2- to 5-year-olds reported regular visits (dental visit every year) and almost half had never seen a dentist. Only 43% of children in this age group reported a visit in the last 12 months. In 6- to 18-year-olds the number with at least one visit in the previous year was much higher – 77%.

[44] The question asked in NHANES III on dental frequency was "How often do you visit the dentist?"

Lewis (2007) used data from National Survey of Children's Health (NSCH) to estimate dental utilization based on at least one preventive dental visit in the last 12 months. The NSCH was conducted in 2003-2004 and surveyed over 100,000 households with children aged 17 years or younger. Information about one randomly selected child in each household was obtained from parents. The study found a significantly higher dental utilization in these children. Overall, 72% of the children in the NCHS reported a dental visit in the previous 12 months.

Yu et al (2001) analyzed Longitudinal Study of Adolescent Health (Add Health)[45] for adolescents over 11 years old and found that only 68% had had a dental visit in the last one year. Kenney et al (2005) using National Survey of American Families (NSAF) data[46] for children from low-income households found only 64% of Hispanic children to have received any preventive dental care in the previous 12 months.

6.3 DISPARITIES IN DENTAL UTILIZATION

The percentage of children with a preventive visit in the last 12 months might appear disconcerting but what is even more appalling is that certain subpopulations have lower utilization rates than the national average. In analyzing dental utilization in the United States for children between 6 and 18 years, Manski et al (2001) found that utilization gap between lower-income and higher-income people increased and that the utilization rates according to sex and race/ethnicity were unchanged in the 20 year-period between 1977 and 1996. Kenney et al (2005) also found gaps between poor and rich children in the frequency of preventive dental visits. Other factors such as non-US

[45] Add Health is a nationally representative survey to measure adolescent health status and behavior. It uses a complex clustered sample of schools and includes personal interviews and questionnaires.
[46] National Survey of American Families surveys over 100,000 children and adults representing non-institutionalized civilian residents of the United States under the age of 65.

citizenship and Spanish-language interviews were also found to correlate with poor preventive dental care. Lewis (2007) came to similar conclusions using NSAF data and reported lower preventive care based on income, insurance, age, and country of birth.

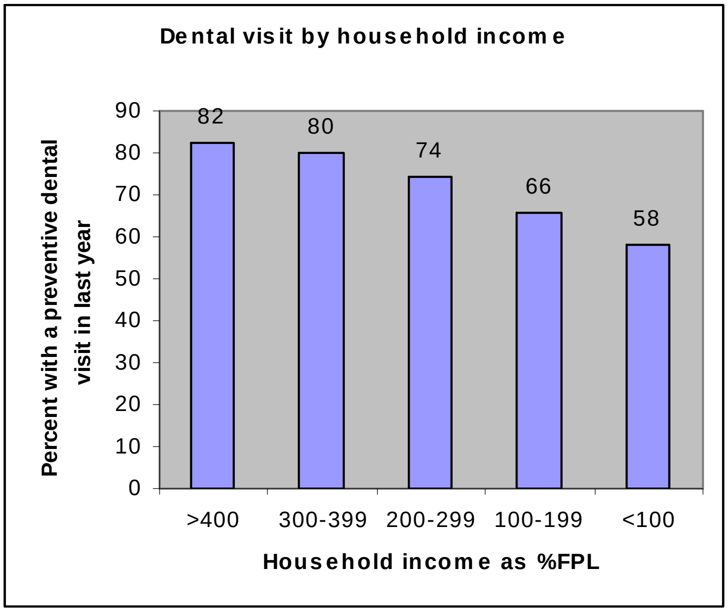
6.4 Factors Affecting Dental Utilization

National survey data on dental visit frequency is much more comprehensive than that for dental caries in the population. Analyses of such data have helped identify several factors that may explain differences in dental utilization among individuals and groups. We discuss the evidence regarding some of these factors in the following section.

6.4.1 Dental Utilization and Household Income

Studies have consistently shown disparities in dental health and dental utilization based on income. The National Center for Health Statistics' (NCHS) data show that of the children who were at or below 200% Federal Poverty Level (FPL) only 62.5% reported a preventive dental visit in the previous 12 months (Lewis 2007). As shown in Figure 6.1, the proportion of children with at least one preventive dental visit in the previous 12 months decreases with decreasing household income.

FIGURE 6.1: Preventive dental visit by household income

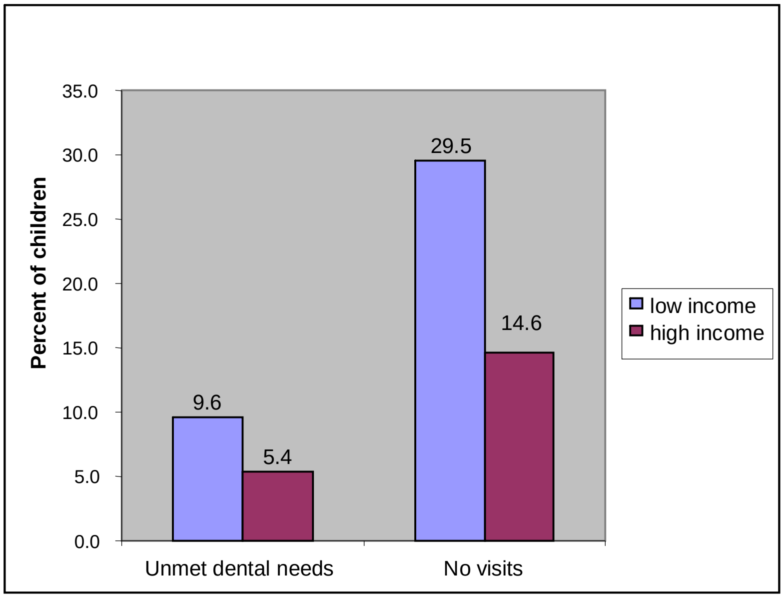


Source: Lewis 2007(based on National Survey of Children's Health)

An analysis of Medical Expenditure survey (NMCES, NMES and MEPS)[47] from three different waves of surveys found that from 1977 to 1996 – a 20-year period – the disparity in the use of dental services between those with household income <200% FPL and those with income >400% FPL increased (Manski 2001). Another analysis of National Survey of America's Families (NSAF) by Kenney et al (2005) also showed serious gaps in prevention and treatment for low-income children (Figure 6.2). They used two variables to look at income differences: those with no preventive dental visits and those with unmet dental care needs. Twice as many low income children (about 30%) had no dental visit as those from high income (about 15%). The differences between the two groups in terms of unmet dental needs were also similar.

[47] National Medical Care Expenditure Survey, National Medical Expenditure Survey and Medical Expenditure Panel Survey.

FIGURE 6.2: Dental care and household income

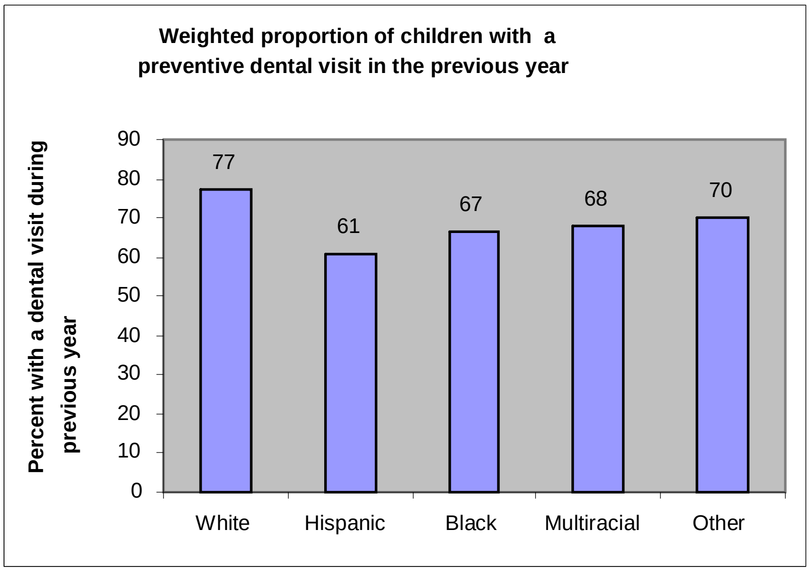


Source: Kenney 2000. (Based on National Survey of America's Families 1997)

6.4.2 Dental Utilization and Race/Ethnicity

Racial and ethnic disparities affect prevalence, dental care, and treatment of oral disease (Fisher 2004). Very few studies have looked at dental utilization in mainly Hispanic populations in the United States. Most information regarding disparities in dental utilization between Hispanic and non-Hispanic children is derived from national surveys. Analysis based on Add Health data showed that Hispanic children and adolescents were more likely than their non-Hispanic white counterparts to have not had a dental visit during the last 12 months (45% vs 27%) (Yu 2001). Children with non-White ethnicity and not born in United States or whose parents were not English-speaking were also significantly less likely to have had a preventive dental visit in the last one year (Lewis 2007). Lewis (2007) analyzed National Survey of Children's Health and found that Hispanic children had the lowest rate of receiving preventive dental visits in the last year among all racial and ethnic groups (Figure 6.3).

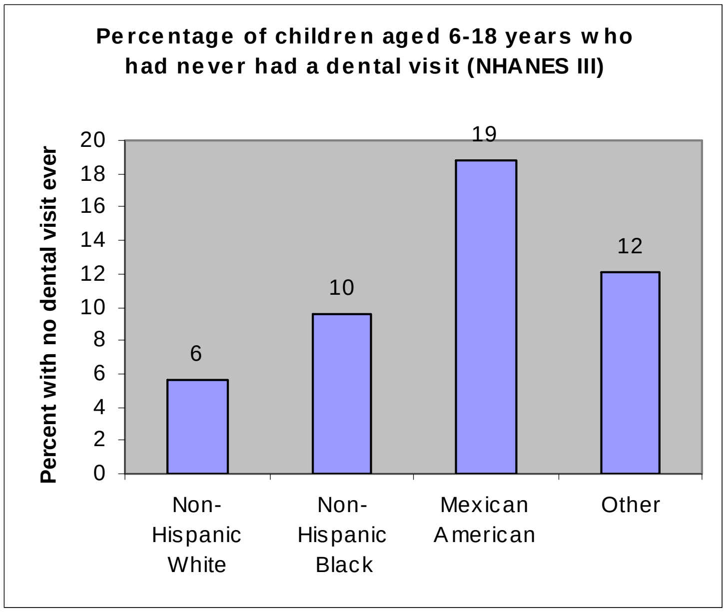
FIGURE 6.3: Children with preventive dental visit in the previous year



Source: Lewis 2007 (based on National Survey of Children's Health)

Analysis of NHANES data from 1988-1994 also shows that children from low educated families and ethnic minority groups were less likely to have regular visits to the dentist than children from advantaged backgrounds (Vargas 2002). Mexican Americans were 40% less likely (OR 0.60, 0.43 – 0.84) to have had a previous-year dental visit and less than half (OR 0.46, 0.3 – 0.7) as likely to have regular dental visits compared to their non-Hispanic white counterparts (Figure 6.4).

FIGURE 6.4: Percentage of children aged 6-18 years who had never had a dental visit

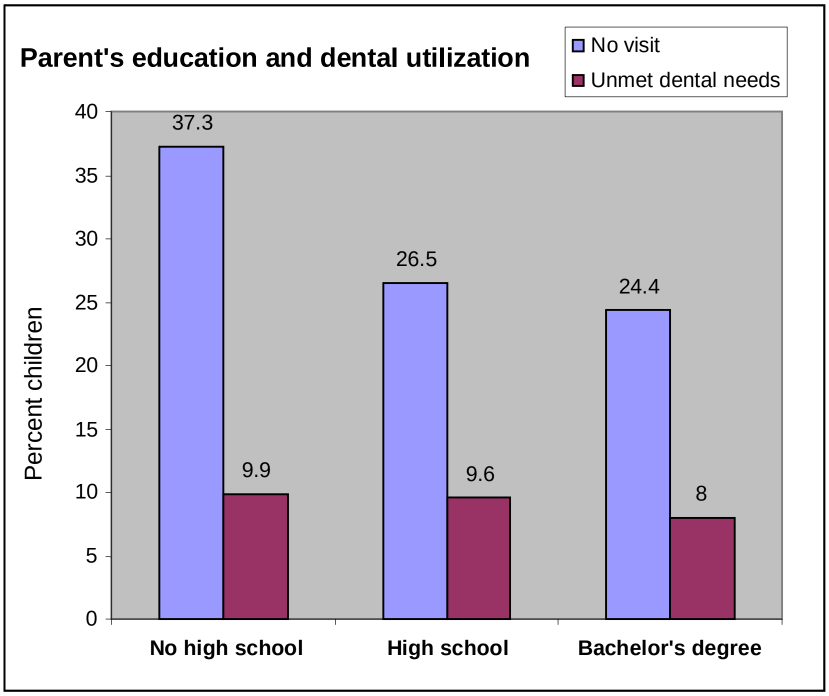


Source: Vargas 2002 (based on National Health and Nutrition Examination Survey 1988-1994)

6.4.3 Dental Utilization and Education

Data from National Survey of America's Families shows a marked difference in utilization of dental care among children of parents with different educational level (Kenney 2000). Children whose parents had not earned a high school diploma were significantly more likely (37%) to have no dental visits in the previous year as compared to those with parents who had high school diploma or more (Figure 6.5). Another analysis of the NSAF data by Yu (2005) confirms the same findings of parental education having an impact on dental utilization of their children.

FIGURE 6.5: Parent's education and dental utilization

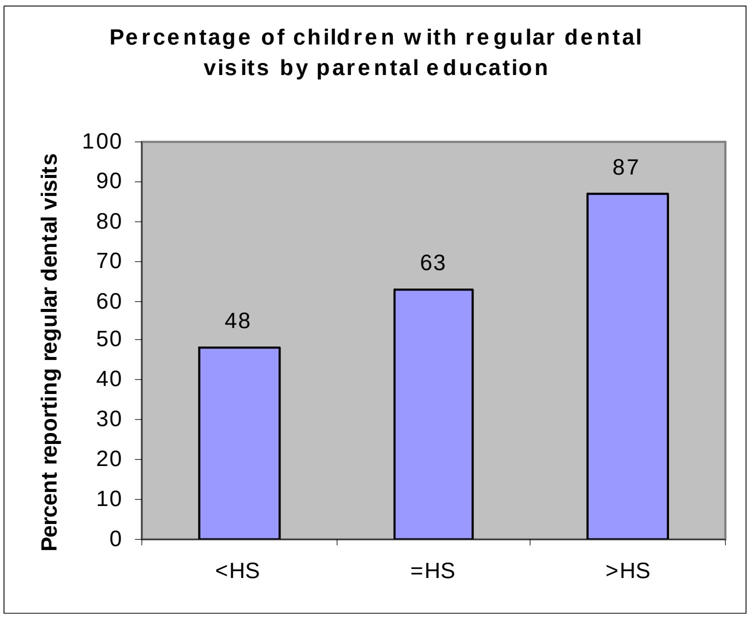


Source: Kenney 2000

Similar effect of parental education has also been observed in other surveys, such as NHANES (Vargas 2002). The data consistently show that parental education has an influence over dental utilization of children (Andersen 1981). Children of parents with a high school diploma (63%) or more (87%) are more likely to have regular dental visits than children whose parents do not have a high school education (48%) (Figure 6.6). NHANES data also showed that children from families with low educational achievement were 3 times as likely to have dental needs as their counterparts from families with high educational achievements (Vargas 2002).

Lewis (2007), using NSCH data, found that children whose parents had a high school or higher education were more likely (74%) to have received a preventive dental visit in the last year as compared to those whose parents had less than a high school education (54%). It is not clear, however, whether in all these surveys the education variable is capturing the parent's dental health behavior, knowledge about prevention or their economic status.

FIGURE 6.6: Percentage of children with regular dental visits by parental education



Source: Vargas 2002 (based on National Health and Nutrition Examination Survey 1988-1994)

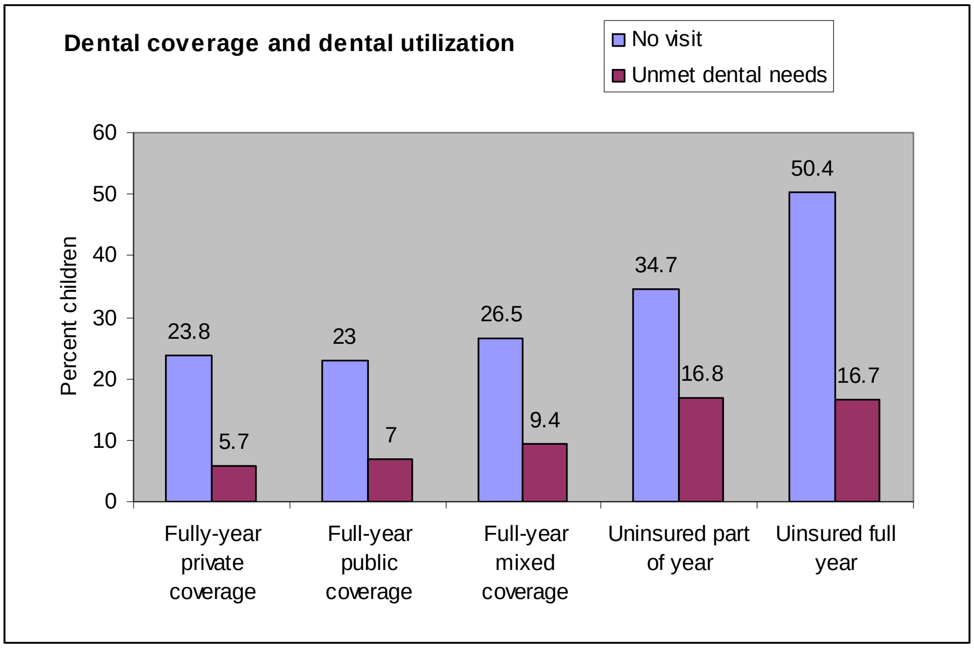
6.4.4 Dental Utilization and Insurance

According to the National Association of Dental Plans, about 150 million people have some form of dental care coverage (Manski 2002). But according to the National Survey of Children's Health almost 9% of the children lack health insurance and 23% lack dental insurance (a ratio of 2.6) (Lewis 2007). The ratio between children who do not have dental insurance and those without medical insurance has almost remained constant (3:1) for the past several years. Several studies have found dental insurance to be an important factor influencing dental care. 1989 NHIS data showed that while 70% of those with dental insurance had at least one dental visit in that year, only half of those without dental insurance reported a visit (Bloom 1992).

Analysis of NSAF shows a correlation between dental coverage and dental utilization. Roughly half of the children with no dental coverage throughout the year had a dental visit while the proportion for those with full coverage (public or private) was around 75% (Figure 6.7). A subsequent analysis of the same survey found that 17% of all low-income children had no insurance coverage. It also found that low-income children who had public coverage were significantly more likely to have had a preventive visit than even children with private insurance without dental benefits (Kenney 2005).

Similarly, using MEPS data Manski et al (2002) found that those with private dental coverage were twice as likely to have had at least one visit in the previous year (52.7%) than those without private dental coverage (25.7%).

FIGURE 6.7: Dental coverage and dental utilization



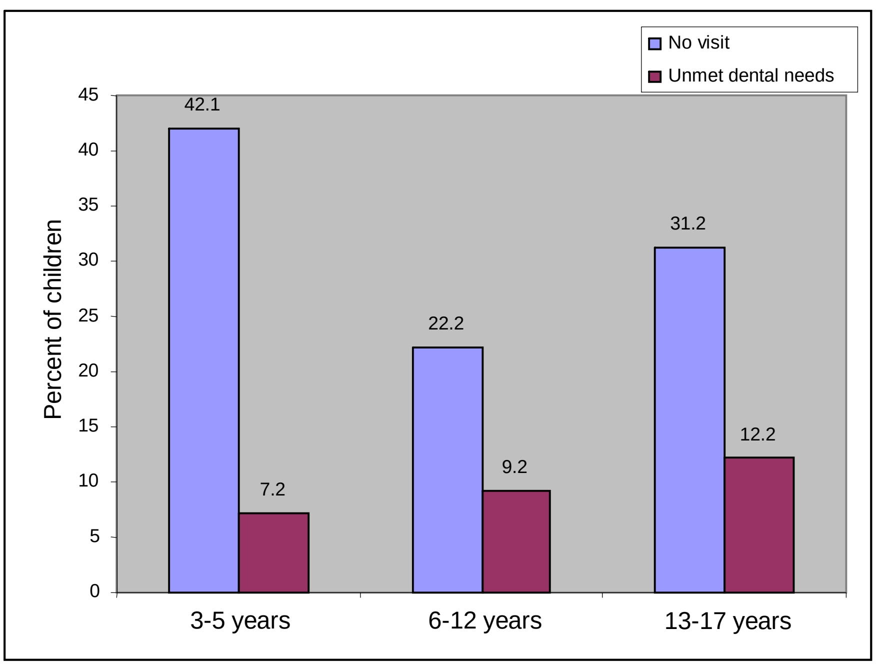
Source: Kenney 2000 (National Survey of America's Families)

On the contrary, evidence also shows that for children, having dental coverage does not always accurately predict dental care utilization. Children from low-income families who are Medicaid eligible and entitled to comprehensive coverage are less likely to seek dental care than those from high-income families without dental coverage (Mouradian 2000). It was noted in a report published in 1993 that less than a fifth (<20%) of children enrolled in Medicaid received preventive dental care (US Inspector General 1996). More recently, Watson et al (2001) analyzed state of Maryland's Medicaid data and found that only 16.7% of eligible children utilized dental services.

6.4.5 Dental Utilization and Age

Younger children have an inordinately large gap in dental needs and dental utilization. National surveys such as NHANES, NSAF and MEPS all show that dental utilization for 2- to 5-year-olds is well under the recommended frequency across all groups but especially so in low income, ethnic minority children. This could be due to an ambiguity in the recommendations, where the American Association of Pediatric Dentistry has only recently changed its recommendation of the first dental visit for a child to be within the first year rather than within 3 years, as previously stated (Vargas 2002). Data from NSAF showed a significant difference in children with no dental visit between younger and older children (Figure 6.8). Lewis (2007) also found a highly significant ($p < .0001$) difference in preventive dental visit in the last year between children aged 1-5 years (48%) and 6-17 years (81.7%).

FIGURE 6.8: Child's age and dental utilization



Source: Kenney 2000.

6.4.6 Dental Utilization and Language

Flores (2002) showed that proportion of Hispanics in dental workforce is a factor in limiting access to dental services for latinos in America. Less than 3% of dentists in America are of Hispanic origin and even fewer demonstrate competence in understanding Hispanic culture of first-generation immigrants. It is argued that low dental care utilization in Hispanic children is related to language and cultural barriers between the providers and the patients (Vazquez 2003). Those who do not speak English easily are more likely to have limited access to dental care services due to the structural problems of the delivery system. This may also explain the low Medicaid utilization in low income minorities. In contrast, Andersen et al (1981) found little evidence that "language problems are a significant barrier to Hispanics' seeking care" in the Southwestern United States.

6.4.7 Dental Utilization and Perceived Needs

There is some discussion in literature about perceived needs for dental care influencing dental visits. However, Vargas (2002) found that children who had a perceived need for dental care were half as likely to have regular dental care as children with no dental needs.[48] This study showed that dental care utilization is not a result of perceived dental needs. Factors that cause poor oral health might also be barriers to dental utilization, hence explaining for the low regular dental care in children with higher perceived needs.

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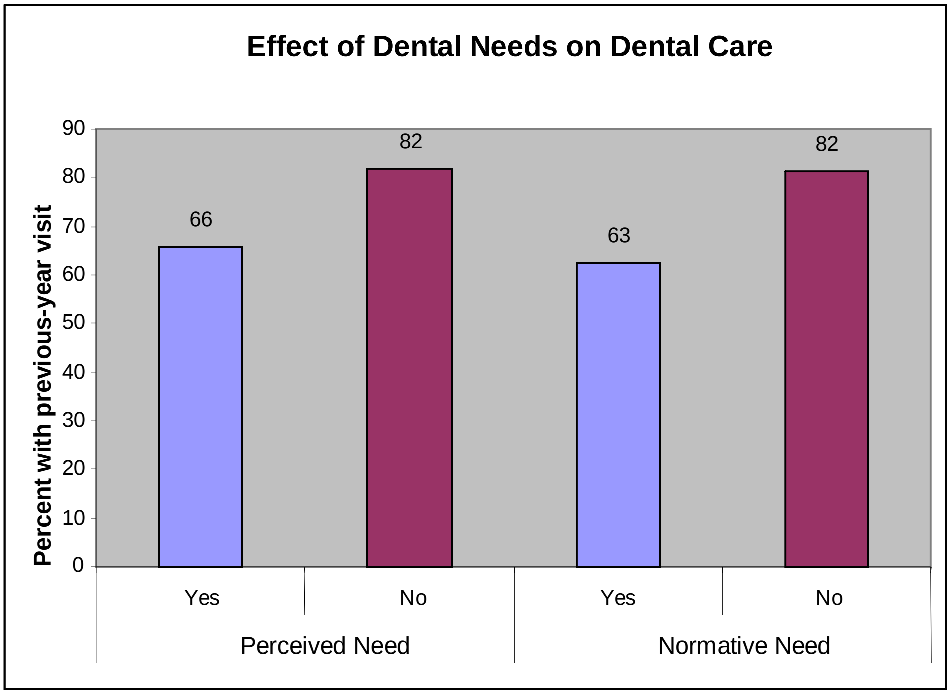
[48] Vargas (2002) differentiates between perceived needs and normative needs. Perceived needs are defined by patients while normative needs are defined by a dental professional after an examination. Vargas found the correlation between perceived needs and normative needs to be low (0.344 for all children).

FIGURE 6.9: Effect of perceived dental needs and dental care



6.5 CAUSES OF DENTAL CARE UTILIZATION DISPARITIES IN HISPANICS

6.5.1 Factors Unique to Hispanic Children

Kim (2005) studied dental care utilization by Hispanic children aged 2-4 years in Chicago. Mothers who believed in importance of preventive dental care for their children were 4 times more likely to continue dental care than mothers who did not. However, the interaction of mother's attitude towards preventive dental care and mother's education were not found to be significant. According to this study, the attitude of mother's peers described by Kim as "social network affirmation of the importance of taking the child to the dentist on a regular basis" was a more important factor in determining the mother's attitude towards preventive dental care.

Some researchers also ascribe the differences in dental utilization on certain unique cultural norms in the Hispanic community. For instance, data from a household survey conducted in Southwestern United States found that Hispanics were more likely than other ethnic groups to consult lay people or friends on what to do about their illness. The same analysis also showed that 33% of Hispanics considered "home remedies" better than "prescribed medicines" compared to 24% in the general population (Andersen 1981). There are other unique features of the Hispanic population that play a more important role in influencing dental or health care utilization relative to other ethnicities. Immigration status, fluency in English language, and family links across the border are some features which are unique to Hispanic populations. These factors play a role in the dental behavior and access to services particularly in the border population of Hispanics.

6.5.2 Other Factors affecting Dental Utilization

Vargas et al (2002) construct a model of previous-year visit and use age, sex, race, adult respondent's education, and perceived and normative needs for dental care as right hand side variables. Manski et al (2002) analyze dental use (the dependent variable being equal to 1, if one or more dental visits during the previous year, and 0 otherwise) and impact of private dental coverage using MEPS data. In another study, Manski et al (2001) analyze NMCES 1977, NMES 1987, and MEPS 1996 data to study dental utilization over 20 years in persons up to age 65 years. They use age, sex, race/ethnicity, income, education, and employment status as their key explanatory variables.

A logistic model for preventive dental care in the last one year, used by Yu et al (2001), found significant relationship between no dental examination and household income, place of birth, race/ethnicity, age, and health insurance in 11- to 21-year-olds. In their analysis the likelihood of not having a dental visit in the last year increased for males, older children, Hispanic and other minorities, children with no health insurance, children born outside the US, those with low household income, and whose parents had less than high school education.

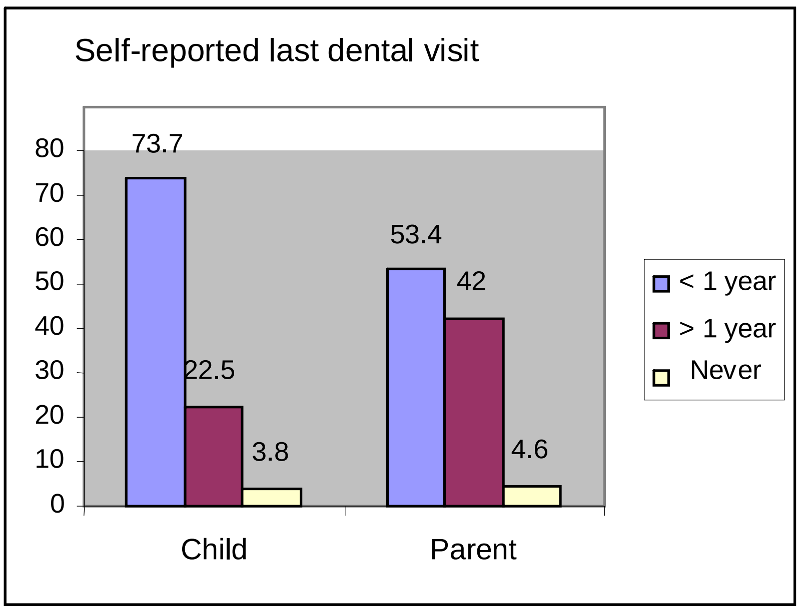
Kim (2005) conducts a survey of Hispanic children (4- to 8-years old) in a study that examined community level factors such as dental care system, provider availability, convenience of accessing dental care and care coordination. A Generalized Linear Model showed that provider availability, dental insurance (including Medicaid) and family income were related to frequency of dental visits in Hispanic children. Mother's values regarding preventive dental care and its benefits also played a significant part in determining which children had a dental visit during the previous year. Lewis (2007) runs logistic regressions to analyze preventive dental visit in the last one year in less than 17-year-olds using age, race, household income, dental insurance (any or none), personal doctor, MSA status, place of birth (United States or outside), language, parent's education and employment status of parent or respondent.

6.6 SURVEY RESULTS FROM LYFORD SCHOOL DISTRICT

Based on literature review, we arrive at similar variables as Lewis (2007). The differences include not having MSA status, since all the children in our sample were from the same school district. We also use Aday and Andersen (1974) model for access to health services to identify predisposing and enabling variables that determine health seeking behavior. Predisposing variables in children include their gender, age, race, ethnicity, place of birth, and language spoken at home. Enabling factors include household income, insurance coverage, and parent's education.

We measure dental visit utilization by asking parents if their child's last dental visit was within one year, more than one year ago, or the child never had a dental visit. The results of that survey show that almost 74% of children had a dental visit within the last one year. This is much higher than the same for their parents, which is only 53% (Figure 6.10). Almost 4% of these children had never had a dental visit in their life.

FIGURE 6.10: Self-reported last dental visit in our survey



The results of our survey show a slightly higher utilization rate than data from Add Health (National Longitudinal Study of Adolescent Health)—a national survey of adolescents.[49]

[49] Yu reported that 68% adolescents (55% if they were Hispanic) in the Add Health data had a dental examination in the past year. The study sampled children in grades 7-12 and their parents.

6.6.1 Model Specification

This part of our data analysis focuses on dental visit frequency as an outcome variable. We define dental visit frequency as a binary variable in the following way:

dental visit frequency = 1, if last dental visit ≤1 year

dental visit frequency = 0, otherwise

We do not differentiate between a preventive dental visit versus a treatment or curative dental visit. Some times both preventive and curative treatments may occur in the same visit and most times parents do not know how to categorize a certain visit to the dentist's office.

The purpose of this analysis is to analyze what factors will affect the frequency of dental visits for children and adolescents. An analysis of factors affecting dental utilization in this population will help in our understanding of what policies may help in increasing dental utilization in underserved populations and hence help improve dental care where it is needed the most.

We use dental caries and socioeconomic variables from our data to estimate how these factors affect the frequency of dental visits in our sample. Our hypothesis is that the frequency of dental visits in children varies depending on their oral health. Children with poor oral health will be more likely to visit a dentist than those with good oral health. Since oral health is also not directly observed, we use dental caries as a measure of oral health. To measure the effect of oral health on dental visit frequency, we also take into account demographic and socioeconomic factors that may influence dental visit frequency such as age, sex, parent's education, and parent's country of birth. Our model also includes what Yu et al (2001) and Aday et al (1974) term as "enabling variables" such as household income, Medicaid eligibility and employment status.

Theoretically, dental visit frequency is a latent unobserved response variable that denotes the tendency to visit a dental professional for oral health care. The observed discrete variable is generated by this underlying continuous variable crossing certain thresholds (Heckman 1978). We assume the latent or unobserved variable y^* related to the observed independent variables x_i by the structural equation:

$$y^* = x_i \beta + \varepsilon_i \qquad (1)$$

where i is the number of observations and ε is the random error term with mean zero.

The link between the observed binary dependent variable y_i (dental visit within one year or not) and the latent variable y^* can be shown with the simple equation:

$$y_i = 1 \quad \text{if } y^* > 0$$

$$y_i = 0 \quad \text{otherwise}$$

So what we actually observe is whether a child had a dental visit in the last 12 months, i.e. 0 or 1 value, for the observed y_i. When y^* is positive, y is observed as 1, otherwise as 0.

The probability of observing y as 0 or 1 can be shown as,

$$\Pr(y = 1 \mid x) = \Pr(y^* > 0 \mid x)$$

which is the same as,

$$\Pr(y = 1 \mid x) = \Pr(\varepsilon > -[\alpha + x_i \beta] \mid x) \qquad (2)$$

The binary regression models, such as logit or probit estimate binary dependent variables by constraining the predicted values $\Pr(y=1 \mid x)$ to be within the range 0 and 1 (Gujarati 2003, p.608). The probit model, for instance, assumes that the error term is independent and identically-distributed, has a mean 0 and has a normal distribution with Var (ε) = 1. The probability is calculated as (Long & Freese 2006, 131-181):

$$\Pr(y = 1 \mid x) = \int_{-\infty}^{\infty+\beta x} \frac{1}{\sqrt{2\pi}} \exp(-\frac{t^2}{2}) dt \qquad (3)$$

The probit function uses the cumulative density function to estimate probability of the event occurring at different values. The estimation is carried out via maximum likelihood method.

In theory, dental visit frequency may be determined by a host of socioeconomic, demographic, behavioral, genetic, and environmental factors. We are limited in using variables that are present in our survey and clinical data of the sample in Willacy County and assume that unobserved variables are uncorrelated with observed variables. The hypothesis of our model is that poor oral health will affect the frequency of dental visits of a child. Since we have no direct observation of measuring oral health status we use a proxy for that variable, which is the presence or absence of dental caries (variable *caries2*). So the simplest relationship can be shown as:

$$\Pr\ (\textit{dental visit frequency} \mid \textit{caries}) = \Pr\ (\varepsilon > -[\alpha + \beta_1\ \textit{caries}]) \qquad (4)$$

However, the probability of having a dental visit in the last one year or not may also be affected by demographic factors such as age (*c_age*), sex (*sex*), and race (*race*) as discussed above. In our sample almost all children are Hispanic, hence we do not use race or ethnicity as a variable, instead our analysis is limited to Hispanic populations. Additionally, socioeconomic factors such as household income (hincome2), parent's education (*p_educ3*), language spoken at home (*lang2*), duration of stay in the county (stayw2), and child's or parent's country of birth (*c_bcountry2* & *p_bcountry2*) may also determine probability of a dental visit in children. Other variables from our data that may influence dental visit frequency are health and dental insurance status of parents (*p_hins* & *p_dins*) and their children (*c_hins* & *c_dins*), Medicaid eligibility of children (*c_medelig*), means of transportation to the dentist (*dtransp2*), sealant application (*seals*), and employment status of the parents (*worktype2*). Hence, the structural equation we use to explain probability of dental caries in our sample is:

$$\Pr(\textit{dental visit frequency} = 1) = \Pr(\varepsilon > -[\alpha + \beta_1\,\textit{caries} + \beta_2\,\textit{sex} + \beta_3\,\textit{age} + \beta_4\,\textit{parent's education} + \beta_5\,\textit{household income} + \beta_6\,\textit{parent's health insurance} + \beta_7\,\textit{stay in Willacy} + \beta_8\,\textit{parent's country of birth} + \beta_9\,\textit{language spoken} + \beta_{10}\,\textit{child's Medicaid eligibility} + \beta_{11}\,\textit{child's dental insurance} + \beta_{12}\,\textit{parent's work type} + \beta_{13}\,\textit{sealants} + \beta_{14}\,\textit{transport for dental visit} + \beta_{15}\,\textit{crossing border for child's dental care}]) \quad (4)$$

or more simply,

$$\Pr(\textit{dental visit frequency} = 1) = \Pr(\varepsilon > -[\alpha + \beta_1\,\textit{caries} + \textstyle\sum_k \beta_k x_k]$$

where x_k are sociodemographic and enabling variables such as *sex*, *hincome2*, and *p_hins*. All variables are binary except for age (*c_age*) which is a continuous variable. Detailed description of each variable used in the analysis is given in Appendix 6. A.

6.6.2 Concerns for Endogeneity in the Model

It is possible that there is an endogeneity in our proposed model of dental visit frequency. As described by Wooldridge (2002, pp. 50-51) such endogeneity may be due to (a) omitted variables caused usually by data unavailability or inability to measure a certain characteristic; (b) measurement error where we are forced to use a proxy to measure a variable of interest; (c) simultaneity when the explanatory variable is determined by some of the same factors as those affecting the dependent variable. We would like to rule out the possibility that oral health status as measured by dental caries in our model may be endogenous. So while a dental visit may result from a child's experience of having dental caries, there may be a reverse effect of regular preventive dental visits affecting dental caries occurrence in children.

As already discussed in the previous chapter, dental caries may be affected by a host of factors. Many of these factors are already included in the structural equation for dental visit frequency. Since both dental visit frequency and dental caries are affected by the same factors there is a possibility of endogeneity in our model which we can test empirically. However, for multivariate equation models we use the reduced form equation for the suspected endogenous variable *caries2*:

$$\Pr(\textit{caries} = 1) = \Pr(\varepsilon > -[\ \alpha + \delta_1\ \textit{sex} + \delta_2\ \textit{age} + \delta_3\ \textit{parent's education} + \delta_4\ \textit{household income} + \delta_5\ \textit{parent's health insurance} + \delta_6\ \textit{stay in Willacy} + + \delta_7\ \textit{crossing border for child's dental care} + \delta_8\ \textit{parent's country of birth} + \delta_9\ \textit{language spoken} + \delta_{10}\ \textit{child's Medicaid eligibility} + \delta_{11}\ \textit{child's dental insurance} + \delta_{12}\ \textit{parent's dental insurance}]) \qquad (5)$$

or simply as,

$$\Pr(\textit{cariess} = 1) = \Pr(\varepsilon > \alpha + \textstyle\sum_k \delta_k x_k)$$

where x_k represent sociodemographic and enabling variables that affect caries. We test for the endogeneity using standard econometric techniques as described by Baum (2006) and Wooldridge (2002). However, we may also suspect that another right hand side variable, sealant application, may be endogenous to the model. To rule out any possibility of simultaneity of dental visit frequency with sealant application we also need to test for endogeneity between these two variables. Since we will now test for two potential endogenous variables in the structural equation (4), we will have to use multivariate probit models to test for endogeneity.

We use estimation of multiple equation probit models using maximum simulated likelihood method (Cappellari and Jenkins, 2003). The variance-covariance matrix of the cross-equation error terms has values of 1 on the leading diagonal and the off-diagonal elements are correlations to be estimated as rho_{ij}. The estimation technique uses the Geweke-Hajivassiliou-Keane (GHK) simulator to evaluate multidimensional likelihood functions. The GHK simulator is based on the fact that multivariate normal distribution function can be expressed in terms of sequentially conditioned univariate normal distribution functions. The GHK simulator uses random draws from standard normal distributions and recursively computes multivariate probability values through a process of replication. It then calculates simulated probability as the arithmetic mean of the values of the simulated probabilities from each replication. We use this procedure because the simulated maximum likelihood (SML) estimator is consistent in large samples and asymptotically equivalent to the true maximum likelihood estimator. Our main interest in using multivariate probit models using GHK simulator is to perform post-estimation tests for endogeneity when there are more than one right hand discrete variables in an equation.

With endogeneity suspicion involving two binary endogenous variables in the structural equation (4), multivariate probit models are useful estimation technique as explained in the previous chapter. The multivariate probit estimation uses a structural equation for outcome variables and reduced form equation for endogenous variable. These reduced form equations have all exogenous variables and any instrumental variables but do not have the outcome and endogenous variables on the right hand side of the equation. The multivariate probit model can be shown as under:

$$\textit{dental visit frequency} = l_1\,(\alpha_{21}\,\textit{caries} + \alpha_{22}\,\textit{sealants} + x_{21}\,\beta_{21} + \varepsilon_{21} > 0) \qquad (6)$$

$$\textit{caries} = l_2\,(\qquad\qquad\qquad x_{22}\,\beta_{22} + \varepsilon_{22} > 0) \qquad (7)$$

$$\textit{sealants} = l_3\,(\qquad\qquad\qquad x_{23}\,\beta_{23} + \varepsilon_{23} > 0) \qquad (8)$$

$$(\varepsilon_{21}, \varepsilon_{22}, \varepsilon_{23} \mid x_{21}, x_{22}, x_{23}) \sim N\,(0,0, 0,1, 1,1, \rho_{212}, \rho_{213}, \rho_{221}, \rho_{223}, \rho_{231}, \rho_{232})$$

where l (..) is the indicator function that takes the value of 1 if the statement in the parenthesis is true and zero otherwise. α and β are regression coefficients and N(..,..,ρ) indicate standard bivariate normal distribution with correlation coefficients ρ. When ρ is zero the model for caries will be a standard probit. The likelihood function in this case contains multivariate joint probabilities. The GHK simulated maximum likelihood estimator is used to estimate these joint probabilities and test whether we can accept or reject the hypothesis that these joint probabilities are zero. If the null hypothesis is rejected, it means that there is endogeneity in the model. However, if the null hypothesis cannot be rejected, that shows that we cannot reject the hypothesis of no endogeneity in the model. Such a result will also mean that our estimated coefficients will not be biased and inconsistent if a univariate probit equation was used instead of the multivariate probit model. We would prefer to use univariate probit models for out estimation because the univariate models place less constraining assumptions than multivariate probit models.

We know that in the presence of endogeneity maximum likelihood estimators are biased and inconsistent. It is therefore important to test for endogeneity in econometric models. When dichotomous variables are involved as the outcome and the explanatory variables, the estimation can be done using probit models. In case there is no correlation between the error term ε_i of the equations used to perform a multivariate analysis, the hypothesis that the explanatory variables are exogenous cannot be rejected. In such situations a univariate model can be used for estimation without the obvious threat of unbiased and inconsistent estimators.

Monfardini and Radice (2006)tackle the complex issue of reliable testing for the exogeneity hypothesis in multivariate probit models by comparing different exogeneity test statistics. They examine four such tests: Lagrange Mulitplier, Conditional Moment Tests, Likelihood Ratio and Wald test. The exogeneity condition in the case of multivariate probit models is stated in terms of the correlation coefficient, *rho* or ρ, which can be explained as a correlation between the unobservable explanatory variables of the different equations in the multivariate model. In the bivariate form, when ρ is zero, it means that the outcome variable in the first equation is uncorrelated with the error term of the second equation of the model. However, if ρ is not zero, the outcome variable and error term of the other equation is correlated and therefore endogenous.

This can be explained econometrically as:

$$y^*_{1i} = x_{1i}\ \beta_1 + \varepsilon_{1i} \tag{13}$$

$$y^*_{2i} = x_{2i}\ \beta_2 + \varepsilon_{2i} = \delta_1\, y_{1i} + \delta_2\, z_{2i} + \varepsilon_{2i} \tag{14}$$

where i is the number of observations and ε is the random error term with mean zero and assumed to be independently and identically distributed as bivariate normal. x_{1i} and z_{2i} are vectors of exogenous variables.

Both y^*_{1i} and y^*_{2i} are latent variables and y_{1i} and y_{2i} are observed binary variables, such that

$y_i = 1 \quad \text{if } y^* > 0$

$y_i = 0$, otherwise

If,

$H_0 : \rho = 0$

and,

$H_1 : \rho \neq 0$

the null hypothesis says that there is no correlation and hence we cannot reject that the variables are exogenous.

Monfardini and Radice (2006) use simulation set-up to obtain maximum likelihood estimates of bivariate probit models using the four tests for exogeneity mentioned above. The authors find that Likelihood Ratio test systematically "outperforms the other tests for all values of N and different nominal levels." They recommend likelihood ratio test for exogeneity hypothesis in bivariate and multivariate probit models. We would therefore use the likelihood ratio test to examine whether the variables that we suspect as endogenous are in fact endogenous or not.

6.6.3 Summary Statistics

Almost three-fourths (74%) of the children in our sample who responded to this question had been to the dentist's office at least once during the previous 12 months (Table 6.1).

TABLE 6.1: Dental visit frequency variable

	Frequency	Percent	Cumulative
≤1 year	154	73.68	73.68
> 1 year	55	26.32	100.00
Total	209	100.00	

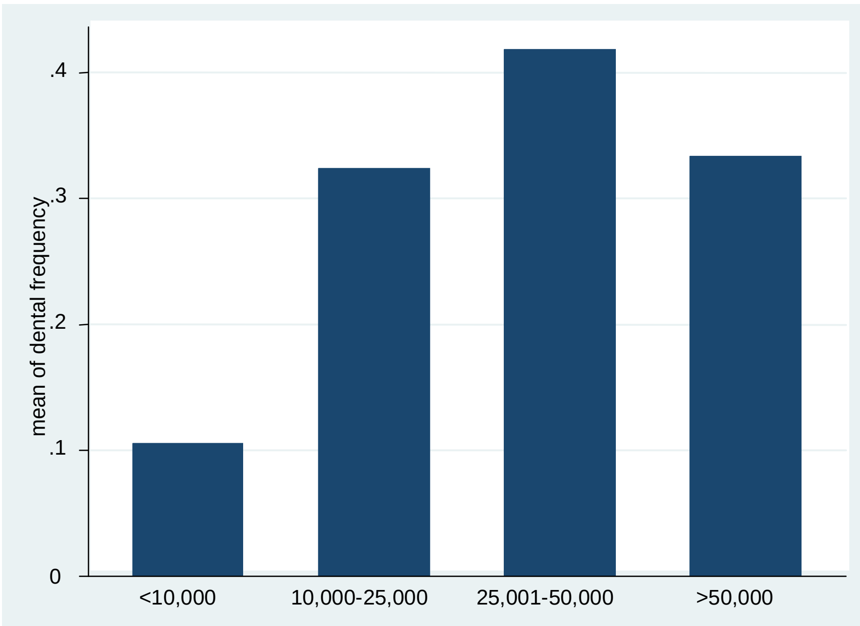
Dental visit frequency does not show any particular pattern with age of the child (Table 6.2).

TABLE 6.2: Dental visit frequency and child's age in years

	Number of children with last dental visit in	
Age in Years	**<1 year**	**> 1 year**
8	9	5
9	25	5
10	24	10
11	23	11
12	17	8
13	22	10
14	14	5
15	8	0
16	4	1
17	6	0
18	1	0

However, when plotted against different household income levels, there seems to be a higher percentage of children with high income who have had a dental visit within the last one year (Figure 6.11).

FIGURE 6.11: Mean dental visit frequency and household income in Dollars



When grouped by the presence or absence of dental caries in a child, there appears to be no difference between those who had a dental visit in the last one year and those who did not (Table 6.3). In both groups of children with high and low frequency of dental visits, the proportion having dental caries was 44%. The null hypothesis that the population mean of dental visit frequency is the same for both groups cannot be rejected (Pr > 0.987)). This means that there is no difference in the dental visit frequency of those children who had caries and those that did not.

TABLE 6.3: Dental visit frequency and dental caries

		Any caries		
		No	Yes	Total
Dental Frequency	≤1 year	87(56%)	67(44%)	154 (74%)
	> 1 year	31(56%)	24(44%)	55 (26%)
	Total	56%	44%	209

6.7 ESTIMATION RESULTS

6.7.1 Linear Probability Model Estimation

We start the estimation with a simple Ordinary Least Squares (OLS) regression model to examine the general direction of coefficients. We use several combinations of variables that could be suspected to influence dental visit frequency in children. Those variables that had a weak theoretical basis to be included in the model were tested empirically for inclusion in the model.

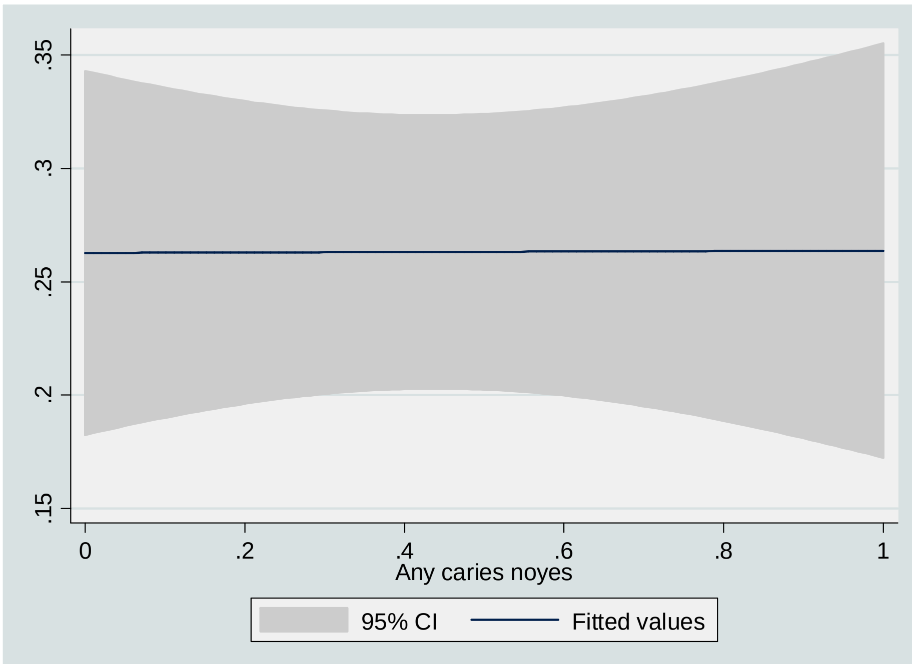
TABLE 6.4: Linear Probability Model of dental visit frequency

Variables	Coef.	Std. Err.	P>|t|
any caries	.029	.074	.698
any sealant	-.056	.099	.576
age	.019	.013	.125
sex	-.123	.076	.518
parent's education high school	-.207	.108	.057
parent's education >high school	-.126	.169	.456

household income >$25,000	-.107	.118	.367
child's dental insurance	.228	.085	.008
parent's health insurance	-.137	.101	.178
stay in Willacy >5yrs	.248	.137	.072
parent's country of birth (not USA)	-.058	.124	.642
crossing border for child's dental	.248	.119	.040
language spoken (English)	.016	.176	.927
child's Medicaid eligibility	.082	.085	.340
work type	-.079	.073	.280
_cons	.458	.249	.068
Obs	126		
Prob > F	.000		

Since dental visit frequency variable in our data has a value 1 if the last visit was within 1 year and a value of 0 otherwise, a positive coefficient means that the variable is increasing the probability of the child having a high dental visit frequency (last visit < 1 year). The results in Table 6.4 show that children with dental insurance, with stay in Willacy county for more than 5 years and who have crossed the U.S.-Mexico border for dental services have a statistically significant greater probability of at least one dental visit in the last one year. Only one variable has a statistically significant effect of reducing the probability of a visit in the last one year, which is if parents of the children have a high school diploma compared to those children whose parents do not have even high school education. However, there is no statistically significant effect if parents have college or postgraduate education.

FIGURE 6.12: Linear regression line with 95% Confidence bands for the conditional means of dental visit frequency and dental caries



A graph of the linear regression line between dental visit frequency and dental caries does not show any significant relationship between the two variables (Figure 6.12). We shall further explore this with binary regression models.

We use Ramsey's omitted-variable regression specification error test (RESET) to test for misspecification of the functional form.[50] According to Baum (2006) the test runs an augmented regression that includes the original regressors, powers of the predicted values from the original regression and powers of the original regressors. The null hypothesis is of no omitted variables so in a misspecified model the null hypothesis will be rejected. Ramsey's test of our model does not reject the null hypothesis (Prob > F =

[50] implemented by Stata's commands: `estat ovtest`

0.5405), thus not rejecting the hypothesis that there is no misspecification of the functional form.

6.7.2 Probit Model Estimation

6.7.2.1 Endogeneity Concerns

Before we determine the estimation techniques for our model described above, we have to address the concern for endogeneity. Endogeneity refers to the simultaneous determination of dependent (or response) variable and regressors. In the absence of endogeneity we can run a univariate model and expect unbiased and consistent results. However, if endogeneity is present then we will have to use econometric methods to account for such relationships in our estimation. The recommended solution to endogeneity in microeconomic models is to use instrumental-variables estimator (Baum 2006, p.185). We test the endogeneity by using instrumental-variables estimation in the linear model first (Table 6.5).[51] The variables selected as instruments have to be exogenous to the model so that they are likely to affect caries occurrence and sealants but do not have an affect on the dependent variable. We choose variables such as knowledge of school-based teledentistry project (*knowmed2*) and if parents have had tooth extractions (*p_extract2*) as instrumental variables (also called excluded instruments). These factors may theoretically affect someone getting caries or sealants application but are not likely to affect dental visit in the last one year.

[51] by using ivreg2 command, a Stata routine developed by Baum, Schaffer, and Stiller (2003) IVREG2: Stata module for extended instrumental variables/2SLS and GMM estimation http://ideas.repec.org/c/boc/bocode/s425401.html

TABLE 6.5: Linear probability with instrumental variables

Variables	Coef.	Std. Err.	P>|t|
any caries	-.038	.137	.782
any sealant	-.451	.985	.647
age	.047	.071	.514
sex	-.029	.081	.723
parent's education high school	-.274	.223	.219
parent's education >high school	-.154	.248	.534
household income >$25,000	-.180	.197	.359
child's dental insurance	.270	.090	.003
parent's health insurance	.004	.250	.986
stay in Willacy >5yrs	.356	.155	.022
parent's country of birth (not USA)	-.179	.137	.191
crossing border for child's dental	.232	.132	.078
language spoken (English)	-.077	.226	.734
child's Medicaid eligibility	.117	.102	.249
work type	.117	.083	.161
_cons	.095	.677	.888
Obs	126		
Prob > F	.000		
Hansen J Statistic			
	Chi-sq	0.025	
	P-val	0.874	

In our model the null hypothesis that caries and sealants are exogenous variables cannot be rejected (P=0.874) based on Hansen J Statistic. This test is a test for overidentifying restrictions and its null hypothesis is that the instruments are valid instruments. The regression results show that we cannot reject the hypothesis that the variable for caries and sealants are exogenous variables in this model.

In our model specification, dental caries may be hypothesized to affect dental visit frequency but dental caries itself may also be the result of not visiting the dentist for preventive care or restoration. Therefore the variable dental caries in children is a candidate for being an endogenous variable in this model. In addition, sealant application may also be considered as another independent variable that may be endogenous in this model. So either sealants have a two-way relationship with dental visit frequency or both sealants and dental visit frequency are dependent on an unobserved exogenous variable. As explained in section 6 about our estimation model earlier in this chapter, our methodology has to take into account the binary nature of our response (dental visit frequency) and endogenous variables (dental caries and sealants). We therefore use multivariate probit models.

The multivariate models use GHK simulator and we rely on the recommended Likelihood Ratio test to check if dental caries and sealants are endogenous to the model of dental visit frequency. For the multivariate probit estimation, we use the structural equation for dental visit frequency (equation 4 in section 6) and reduced form equations for the endogenous variables, sealants and dental caries (equation 4). Since the variables in our model are mostly binary variables, the model may suffer from identification problem. As discussed in the previous chapter, Maddala (1983, p. 122) considers a probit model with two equations and an endogenous regressor to have identification problems. However, Wilde (2000) has shown that the parameters of a probit model with endogenous variables will be identified as long as the model has one varying exogenous regressor. In our model the variable for age fulfills this criterion, hence solving the identification problem.

When we run multivariate probit models, using a user-developed routine in Stata (Jenkins 2003), the results for dental utilization estimation are shown in Table 6.6. The multivariate model shows caries, parent's education, child's dental insurance, and stay in Willacy for more than five years to have statistically significant coefficients. The signs on all other coefficients are the same as in the OLS regression except for parent's country of birth variable which has different signs in Table 6.4 and 6.5, but is not statistically significant in either set of estimated coefficients.

The maximum simulated likelihood estimator is consistent as the number of observations and the number of draws tend to infinity and is asymptotically equivalent to the true maximum likelihood estimator as the ratio of the square root of the sample size to the number of draws tends to zero. Given the relatively small size of our sample we sought to find convergence of our estimator at a relatively large number of draws.[52] The likelihood ratio test ($P > 0.1174$), which is recommended for testing endogeneity in multivariate probit models (Monfardini 2006), shows that we cannot reject the null hypothesis that both sealants and dental caries variables are exogenous to the model. We check the robustness of the results by using different seed numbers and draws but obtain consistent results of the likelihood ratio tests for endogeneity. Some of these results are shown in Appendix 6.B as are the results of a bivariate probit model that we estimated before using the multivariate probit models.[53]

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[52] Stata help for mvprobit routine

[53] The default number of draws for the procedure in Stata is five. We increase the number of draws to 350 with different seeds. The results of the LR test with different draws remain unchanged. Results of various draws and seed numbers can be seen in Appendix 6.B.We also use a combination of algorithm techniques (Broyden-Fletcher-Goldfarb-Shanno and Newton-Rhapson algorithms) to achieve convergence.

TABLE 6.6: Multivariate Probit Model Results (draws#350, seed#212)

variables	Coef.	Std. Err.	P>|t|
Dental Frequency (1= < one year)			
any caries	-.481	4.931	.922
any sealant	-1.258	2.839	.658
sex	-.483	.540	.371
age	.164	.161	.307
parent education high school	-.636	1.567	.685
parents education >high school	-.581	1.683	.730
household income >$25,000	-.418	.551	.448
child's dental insurance	.937	.725	.179
stay in Willacy >5yrs	.779	1.957	.691
parent's birth country (not USA)	-.000	1.482	1.000
language spoken (English)	.236	1.609	.883
crossing border for child's dental	.605	.585	.301
work type	-.458	.315	.147
_cons	-.847	5.886	.886
Any caries (yes=1)			
sex	.059	.233	.800
age	.019	.053	.713
parent education high school	.471	.360	.191
parents education >high school	.644	.553	.244
household income >$25,000	-.436	.320	.173
child's dental insurance	-.188	.320	.557
stay in Willacy >5yrs	-.682	.362	.060
parent's birth country (not USA)	-1.107	.810	.172
language spoken (English)	-.954	.973	.327
crossing border for child's dental	-.258	.466	.581

work type	-.207	.251	.410
_cons	1.350	1.033	.191
Any sealant (yes=1)			
sex	-.253	.278	.364
age	.260	.062	.000
parent's education high school	-.419	.410	.306
parent's education >high school	-.289	.573	.615
household income >$25,000	-.715	.431	.097
child's dental insurance	-.305	.410	.457
stay in Willacy >5yrs	.620	.555	.264
parent's birth country (not USA)	.589	.466	.206
language spoken (English)	.704	.586	.229
crossing border for child's dental	-.147	.605	.808
work type	-.051	.317	.873
_cons	-5.019	1.107	.000
Obs	150		
Prob > chi2	.000		
Likelihood ratio test of rho21 = rho31 = rho32 = 0			
Prob > chi2 = .1174			

More specifically, the null hypothesis states that the correlation coefficient between the different equations and error terms of the multivariate probit model, $\rho = 0$. A rejection of the null hypothesis would have indicated that there is endogeneity in the model. However, in our model we cannot reject the null hypothesis of exogeneity, thus showing that the univariate probit model is likely to be consistent and unbiased. Given these findings, we would prefer to use univariate probit models for estimation because it puts less constraining assumptions during estimation of the model than multivariate models.

6.7.2.2 Univariate Probit Model Estimation

Table 6.7 reports coefficient estimates and standard errors for probit and logit models and compares it with OLS regression. Because we have a dichotomous dependent variable, Model 1 and 2, run the same model using logit and probit models respectively. They use demographic, socioeconomic and health-related variables to understand the variability in the dependent variable of dental visit frequency. Since coefficients from binary regression models are hard to interpret without transformation, we use marginal coefficient effects or dy/dx[54] to measure change in the dependent variable for unit change in regressors. We drop the variable describing transportation used to visit the dentist because it is excluded by the statistical program as predicting success perfectly. We also use robust option in all our models reported below to account for heterosekdasticity which we have already tested to be present.

TABLE 6.7: OLS, Logit, and Probit estimation results with marginal coefficients

	OLS Regression	**Logit Regression**	**Marginal Coefficients of Logit Regression**	**Probit Regression**	**Marginal Coefficients of Probit Regression**
Variables	Model 0	Model 1	Model 1	Model 2	Model 2
any caries	.029	.215	.029	.141	.034
Robust SE	*[.074]*	*[.520]*	*[.069]*	*[.285]*	*[.069]*
any seal	-.056	-.575	-.087	-.318	-.085
SE	*[.100]*	*[.694]*	*[.114]*	*[.380]*	*[.108]*

[54] `mfx` command for logit and `dprobit` for probit models in Stata

age	.019	.151	.021	.091	.022
SE	*[.013]*	*[.100]*	*[.013]*	*[.056]*	*[.014]*
sex (male)	-.042	-.421	-.058	-.252	-.063
SE	*[.076]*	*[.511]*	*[.071]*	*[.279]*	*[.070]*
parent's education =high school	-.207	-2.093	-.266	-1.177	-.267
SE	*[.108]**	*[1.541]*	*[.176]*	*[.666]**	*[.134]**
parent's education >high school	-.126	-1.780	-.326	-.941	-.288
SE	*[.169]*	*[1.826]*	*[.385]*	*[.828]*	*[.284]*
household income >$25,000	-.107	-.641	-.094	-.385	-.101
SE	*[.118]*	*[0.680]*	*[.107]*	*[.396]*	*[.111]*
child with dental insurance	.228	1.665	.211	1.026	.233
SE	*[.085]****	*[0.595]****	*[.080]****	*[.328]****	*[.074]****
parent's health insurance	-.137	-.704	-.101	-.473	-.123
SE	*[.101]*	*[.712]*	*[.113]*	*[.398]*	*[.111]*
crossing border for child's dental care	.248	1.662	.145	1.037	.162
SE	*[.119]***	*[.755]***	*[.049]****	*[.455]***	*[.048]***
stay in county >5yrs	.248	1.601	.307	.961	.312
SE	*[.137]**	*[.789]**	*[.186]**	*[.432]***	*[.166]***
parent born outside USA	-.058	-.099	-.014	.002	.001
SE	*[.124]*	*[1.007]*	*[.141]*	*[.541]*	*[.133]*
language English	.016	.830	.137	.465	.133
SE	*[.176]*	*[1.636]*	*[.312]*	*[.762]*	*.245*
child's Medicaid eligibility	.054	.411	.058	.219	.056
SE	*[.088]*	*[.569]*	*[.084]*	*[.323]*	*[.084]*
work type	-.079	-.633	-.079	-.386	-.088
SE	*[.073]*	*[.663]*	*[.078]*	*[.344]*	*[.073]*
constant	.458	-.778		-.508	
SE	*[.249]**	*[1.771]*		*[.987]*	
Observations	126	126	126	126	126
Pseudo R^2		**.221**		0.228	
F-statistics	**.000**	**.000**		0.000	

As 97.5% of our sample is Hispanic, we run a restricted model for students whose race is Hispanic.[55] Table 6.7 compares results from linear probability model with logit and probit models. The models show that the presence of dental caries does not have a statistically significant effect on dental utilization. The not-statistically-significant impact of dental caries on dental visit frequency holds true in different variations of the probit models as shown in Table 6.9. The same is true for sealant application, which could have theoretically been simultaneously determined with dental visit frequency. But our results show no statistically significant effect of sealant application on dental visit frequency.

An important policy variable that appears to have a strong influence on dental visit frequency is a child's dental insurance status. Children who had dental coverage had 0.23 higher probability to have had a dental visit within the last one year than their counterparts. Dental coverage has been found in other studies to have an important effect on dental utilization as well (Manski 2002).[56] Duration of stay in Willacy County beyond 5 years also had a significant effect in increasing the chances of children having a dental visit during the last one year. Although we do not have a variable on immigration status, stay in the County for less than five years may be capturing those households who are either migrant workers or recent immigrants to the United States. As mentioned above, United States citizenship has been found to be a significant variable in at least one national survey study (Kenney 2005).

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[55] According to Long and Freese (2006, Regression Models for Categorical Dependent Variables Using Stata) if the dependent variable does not vary within one of the categories of an independent variable, this problem of estimation should be resolved by taking out such cases from the estimation. p.192.

[56] Using MEPS data, Manski (2002) found that children with private dental coverage were twice as likely to have visited a dentist in the last one year than those without coverage.

We also find that those children who had traveled across the U.S.-Mexico border to get dental care were more likely to have had a visit in the last one year than those who had not. Our data would not show whether the visit across the border was preventive in nature or curative. It is worth mentioning here that the same variable did not show any significant effect on reducing the probability of dental caries in our sample (Chapter 5).

An interesting result in the probit estimation is that children whose parents had a high school education had a statistically significant less probability of having a visit during the last one year. Parents with college or postgraduate education did not have a statistically significant effect on the dental utilization of their children. This result could also be explained by the dental IQ of parents as discussed in Chapter 5. Since years of school education do not measure the awareness and knowledge of parents about dental behaviors, it is possible that parents with less years of schooling may learn about healthy behaviors from their peers or community.

6.7.3 Logistic Regression Results

We also run logistic models with similar variables as in Model 2 in Table 6.8 to calculate odds ratio. Three variables that stand out as having relatively large odds ratios at statistically significant levels include child's dental insurance (OR 5.28, SE 3.14), stay in Willacy county for more than five years (OR 4.96, SE 3.91), and crossing the border for child's dental care (OR 5.27, SE 3.98). The results of logistic regression confirm estimation results from univariate probit model.

TABLE 6.8: Logistic Model of dental visit frequency

Variables	Odds Ratio	Robust Std. Err.	P>|z|
any caries	1.240	.645	.679
any sealant	.563	.390	.407
age	1.163	.117	.131
sex	.656	.336	.410
parent's education high school	.123	.190	.174
parent's education >high school	.167	.308	.330
household income >$25,000	.527	.358	.346
child's dental insurance	5.285	3.143	.005
Parent's health insurance	.495	.352	.323
parent's country of birth (not USA)	.906	.912	.922
stay in Willacy >5yrs	4.960	3.912	.042
crossing border for child's dental	5.271	3.980	.028
language spoken (English)	2.293	3.752	.612
child's Medicaid eligibility	1.509	.859	.470
work type	.531	.352	.340
Obs	126		
Prob > F	.003		
Pseudo R	0.221		

Finally, we also report a few other models as sensitivity analysis of our selected model (Model 2). Model 3 does not include the parent's education variable, Model 4 excludes language variable, Model 5 takes out parent's health insurance and Model 6 is without parent's country of birth variable. Table 6.9 shows that the results of the estimation are fairly robust and the statistically significant variables from Model 2 remain statistically significant.

TABLE 6.9: Sensitivity Analysis using different probit models

Variables	Probit Regression Model 2	Probit Regression without education Model 3	Probit without language Model 4	Probit Regression without parent's health insurance Model 5	Probit with out parent's birth country Model 6
any caries	.141	.134	.142	-.187	.141
Robust SE	*[.285]*	*[.278]*	*[.287]*	*.278*	*.281*
any seal	-.318	-.121	-.277	-.390	-.318
SE	*[.380]*	*[.363]*	*[.388]*	*.361*	*.380*
age	.091	.077	.087	.093	.011
SE	*[.056]*	*[.051]*	*[.057]*	*.057*	*.056*
sex (male)	-.252	-.304	-.240	-.290	-.252
SE	*[.279]*	*[.276]*	*[.277]*	*.278*	*.278*
parent's education =high school	-1.177	.	-1.049	-1.136	-1.178
SE	*[.666]*		*[.554]**	*.693*	*.641**
parent's education >high school	-.941		-.886	-1.139	-.942
SE	*[.828]*		*[.762]*	*.800*	*.796*
household income >$25,000	-.385	-.399	-.334	-.451	-.385
SE	*[.396]*	*[.382]*	*[.411]*	*.377*	*.394*
child with dental insurance	1.026	.980	1.033	.974	1.025
SE	*[.328]****	*[.305]****	*[.323]****	*.318****	*.327****
parent's health insurance	-.473	-.370	-.456		-.474
SE	*[.398]*	*[.348]*	*[.396]*		*.400*
crossing border for child's dental care	1.037	..892	1.077	.908	1.037
SE	*[.455]***	*[.472]**	*[.448]***	*.468**	*.462***
stay in county >5yrs	.961	1.040	1.011	1.008	.961
SE	*[.432]***	*[.404]**	*[.424]***	*.420***	*.432***
parent born outside USA	.002	.275	-.192	.042	
SE	*[.541]*	*[.543]*	*[.434]*	*.556*	
language english	.465	.012		.410	.463
SE	*[.761]*	*[.684]*		*.779*	*.663*
child's Medicaid eligibility	.219	.269	.226	.314	.218
SE	*[.323]*	*[.316]*	*[.323]*	*.303*	*.332*
work type	-.386	-.573	-.397	-.421	-.386

SE	*[.344]*	*[.324]**	*[.344]*	*.339*	*.341*
constant	-.508	-.923	-.205	-.680	-.505
SE	*[.987]*	*[1.018]*	*[.938]*	*.964*	*.848*
Observations	126	126	126	126	126
Pseudo R^2	0.228	0.193	.225	.219	.174
F-statistics	0.000	0.001	.000	.004	.018

6.8 CONCLUSION

Our data analysis shows that disparities in dental visit frequency in Hispanic children exist. A key policy variable that is strongly influencing this variation in our sample is the dental coverage status of the children. Those children who have dental insurance have 0.23 higher probability of dental visit in the last one year compared to those with no dental insurance. Also, those children whose family has lived in the same county for more than five years have a higher probability of dental visit in the last year. Our estimation results do not show that the oral health status, as shown by presence of dental caries, is a significant predictor of dental visit frequency in Hispanic children. Similarly, Medicaid eligibility did not have a significant effect on dental utilization. This trend is shown in national figures as well, where according to one estimate only 20% of Medicaid eligible children visit a dentist. Our results show that the usual suspects of poverty and lack of education may not be as significant in determining dental utilization among children in Hispanic underserved populations as dental coverage and the length of stay of their families at one place for longer periods of time. The latter may also capture differences between migrant workers, recent immigrants and those who have stable sources of income and stable place of living.

Chapter 7 Cost and Policy Implications

The results of our analysis show a protective effect of preventive care, particularly dental sealant application, on dental caries in children and adolescents. However, we also want to understand the magnitude of this effect under different situations and its implications for policy solutions to poor oral health in the underserved population in our study.

7.1 PREDICTED MODEL FOR DENTAL SEALANT EFFECT

After the regression models, the predicted values let us generate in-sample predictions thereby showing the values of the response variable generated by the fitted model. The mean predicted probabilities for the outcome variable from our model was 0.445 (range: 0.037-0.764). We used predicted models to estimate the probability of caries occurrence in an average child who has a sealant or who does not have a sealant (Table 7.1).

TABLE 7.1: Predicted values of dental caries

	Predictions for *caries2* (mean)	**95% Conf. Interval**	
If an average student has no sealant			
Pr(caries = yes | seals)	0.498	0.422	0.575
Pr(caries = no | seals)	0.502	0.425	0.578
If an average student has a sealant			
Pr(caries = yes | seals)	0.198	0.063	0.333
Pr(caries = no | seals)	0.802	0.667	0.937

The results show that if no one gets a sealant in the sample and the values of all other variables for each child are considered to be at their mean, there will be no difference in the predicted probability to have dental caries among the children. However, if all the students had received any sealant and the rest of the variables were at their mean values, then the probability of caries in the sample would only be 19.8%. This may also be described from the point of view of an average child in our sample as shown in Table 7.1. A child with all variables at mean value of the sample has a 50% probability to have caries without any sealant. But if that child had received a sealant then the probability of getting any caries would only be 19.8% ─ a decrease of 60.2% (probability decrease from .498 to .198).

Table 7.1 performs the simulation of sealant effect on caries when all other variables in our model are at their mean. We also simulate the effect of sealants on caries when these variables are at their observed values for each child and we find similar protective effect. Table 7.2 shows that there is a slight increase in the probability of having caries between the actual observed probability in the sample and the predicted values when everyone had a sealant while keeping all other variables at their mean values (0.445 vs 0.498). However, when all other variables are kept at their observed values and then we simulate the probability of caries when everyone had a sealant, there is a significant decrease of about 52% in the mean probability of caries (from .445 to .213).

TABLE 7.2: Prediction for caries with different assumptions on exogenous variables

	Mean of caries occurrence	**Std Dev**
As observed in the sample		
Pr(caries = yes)	.445	.133
If no students had a sealant and all exogenous variables at their mean value		
Pr(caries = yes | seals)	.500	.093
If all students had a sealant and all exogenous variables at their observed value		
Pr(caries = yes | seals)	.213	.181

In our sample, 81% children did not have any sealant (Figure 7.3). According to the AAPD guidelines, all of them should have had a sealant by the time they were in school. The AAPD guidelines on periodicity of preventive dental examinations recommend that pit and fissure sealants should be applied between the ages 2 and 6 to primary and permanent teeth (AAPD 2003).

TABLE 7.3: Cross tabulation of observed dental caries and sealants

	Any sealant		
Any caries	No	Yes	Total
No	101 72.66% 51.01%	38 27.34% 80.85%	139 100% 56.73%
Yes	97 91.51% 48.99%	9 8.49% 19.15%	106 100% 43.27%
Total	198 80.82% 100%	47 19.18% 100%	245 100% 100%

If these children were given sealants, then from Table 7.2 the probability of having caries in a child will be 0.213. So we would expect a 52% decrease in children with caries in the sample when all other variables are at their observed values. Since 49% of those without a sealant (97/198) had caries in our sample (Table 7.3), if all of these children had got a sealant application, our model would suggest that there will be a 52% decrease in the number of children with caries in this group. That means that in this group (without sealants) the number of children with caries will decrease from 97 to 42. The expected frequencies are shown in Table 7.4.

TABLE 7.4: Predicted probabilities of dental caries if all children had a sealant

	Any sealant
Any caries	Yes
No	194 79.18%
Yes	51 20.82%
Total	245 100%

As shown in Table 7.4, if all the children had sealants in our sample, the prediction of children with caries will decrease to 51 (including those who already had sealants in the observed sample) from the observed total of 106 – a 52% decrease.

7.1.2 Some Caveats

The estimates and simulations we present here are conservative in several respects:

1. We only use the presence of any sealant as a measure of preventive care and count a failure in this case as any caries on any tooth. This means that we are not actually measuring the effect of sealant on the specific tooth where sealant is applied. There is, therefore, the possibility that someone with sealants on molar teeth may have caries on some other tooth where sealants were not applied and where sealants could not have played any protective role against caries. Almost 90% of dental caries occur on pit-and-fissure surfaces (Ripa 1993) but there are still 10% that may occur

on other surfaces or teeth where sealants are not applied in routine preventive care. This will mean that we are underestimating to some extent the effect of sealants on dental caries in our model.

2. Pit-and-fissure sealants are only one type of preventive care that children may receive to minimize the likelihood of caries. We did not have data on nutrition and fluoridation in addition to other behaviors that may affect caries in children. Community fluoridation is the other major concern that needs to be addressed in Lyford because their natural fluoride levels in surface water are not optimal.[57] The data reported by the state of Texas to the National Center for Chronic Disease Prevention and Health Promotion, show that the water supply to Willacy County comes from natural surface water.[58] While there may be differences in dental health behaviors and nutrition among individuals, the role of community water fluoridation would not vary. A pit-and-fissure sealant program can easily add such preventive services as fluoride varnishes or providing fluoride toothpastes to add to the protective effect of the program. But we do not include these possibilities in our analysis.

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[57] Optimal fluoride levels recommended by the U.S. Public Health Service and CDC for drinking water range from 0.7 parts per million (ppm) for warmer climates to 1.2 ppm for cooler climates. Lyford has water supply from surface using a community system. The two major water systems in Willacy from City of Lyford and Raymondville have natural fluoride concentrations (0.20 mg/L) that are below the level considered optimal for prevention of dental caries. National Center for Chronic Disease Prevention and Health Promotion. http://apps.nccd.cdc.gov/MWF/Index.asp

[58] The per person cost of fluoridation varies by the size of the community population. The average cost of providing fluoridated water to communities with more than 20,000 residents is about 50 cents per year. For communities of 10,000–20,000 residents, the cost is about $1, and for those living in communities of less than 5,000, the cost is about $3 per year. http://www.cdc.gov/nohss/guideFL.htm

3. In measuring the protective effect of preventive care in general and sealant application in particular, we also do not include the effect of dental education and health awareness that occurs during the process of receiving a sealant. Dental professionals usually provide useful tips to children during such procedures or examinations which may go a long way to improved habits in these children. Many children never get even a visual examination of their teeth by a dental professional or by their parents resulting in severe damage before tooth decay is noticed and treated. Sealant application provides an opportunity for a dental professional to check for early signs of caries, periodontal disease, tooth injuries or other oral disease. We do not take these factors into our calculation as well because we do not have data on these benefits.

7.1.3 Predicted Dental Sealant Effect for Different Household Income Levels

We also estimate the predicted dental caries in our sample based on sealant application and different household income levels. Table 7.5 gives an overview of the number of children in the sample who belong to low-income household (<$25,000 annual income) and those above that income threshold by presence of dental caries. It shows that children from low-income households are a little more than two thirds of the student population (69%) and have more than three-fourths (76%) of dental caries. Within each income category, those in low income category have a 1:1.1 ratio between those with and without caries; while that ratio in high income children is 1:2.

TABLE 7.5: Dental caries and household income

	Any caries		
Household Income	No	Yes	Total
Low (≤$25,000)	88 52.38% 63.31%	80 47.62% 75.47%	168 100% 68.57%
High (>$25,000)	51 66.23% 36.69%	26 33.77% 24.53%	77 100% 31.43%
Total	139 56.73% 100%	106 43.27% 100%	245 100% 100%

We predict the mean probabilities of the outcome variable, *caries2*, in our fitted model according to different household income levels. The first scenario in Table 7.6 shows that at observed values in our sample, if we simulate the effect of every child having a sealant application, the mean probability of caries in the children will be less than 20%. As already shown in Table 7.3, this is in contrast to about 43% of the actual sample that had caries and about 50% of the children in the case when no one had a sealant.

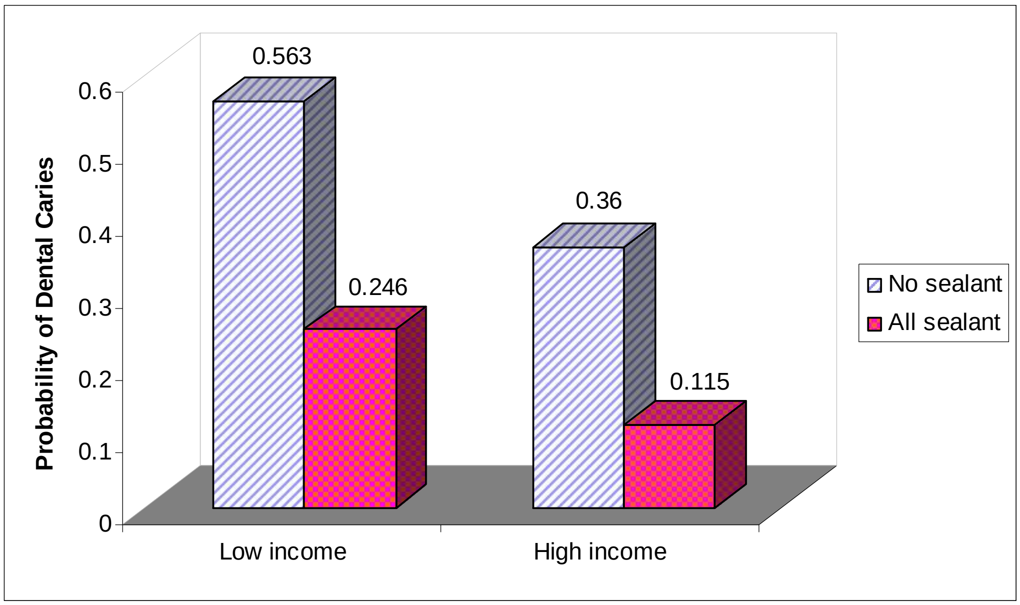
Since household income is a statistically significant variable in our model of dental caries, we simulate the impact of dental sealants in populations with different household income levels (Table 7.6). Based on our fitted model, if sealants were applied to all children who were from a low-income household, the effect of sealant application for all children will be about 56% decrease (.563 to .246) in the mean probability of caries compared to a situation when none of these low-income children had any sealant. When we compare the mean probability of caries in low-income children with no sealants with high income children with no sealants, there is a 36% decrease in the mean probability (.563 to .360) in high-income children. And if low-income children who do not get sealants are compared to high-income children who do get sealants, the mean probability of having caries is about 80% higher (.563 vs .115) in low-income children.

TABLE 7.6: Predicted dental caries at different household income levels

	Mean probability of caries	**Confidence intervals by delta method**	
If everyone has sealant at observed income levels			
seals=1	.198	.063	.333
If no one has sealant and all are from low income household			
seals=0, hincome2=0	.563	.471	.655
If everyone has sealant and all are from low income household			
seals=1, hincome2=0	.246	.089	.404
If no one has sealant and everyone is from high income household			
seals=0, hincome2=1	.360	.233	.487
If everyone has sealant and all are from high income household			
seals=1, hincome2=1	.115	.005	.225

These significant differences in probabilities, as depicted graphically in Figure 7.1, show that those in greatest need of dental sealant applications will also have the highest probability of having dental caries.

FIGURE 7.1: Predicted probability of dental caries at different household income levels in our data



We looked at predicted decrease in relative dental caries occurrence in our population with other combinations as well (not reported here), such as for an average child who is from low income and also has parents with low education. The predicted relative decrease was around 50% as seen for low income children. Similarly we also looked at a low-income child who has not lived in Willacy County for more than 5 years. The relative decrease was not too different than for someone from low-income household with all other variables at the sample mean.

7.1.4 Measuring Sealant Effect in Different Situations

We have looked at dental caries occurrence in an underserved school-age population and measured the effect of any sealant application on preventing caries. Our model for dental caries describes the various factors and their possible contribution in explaining differences in dental caries in children with different socioeconomic and demographic characteristics. We can use this information to simulate the effect of sealants in different scenarios and thereby increase our understanding of related policy options to decrease caries in such underserved populations.

As summarized in Table 7.7, we have predicted decrease in mean probability of caries based on our fitted model in four different scenarios:

Scenario 1: when dental sealants are applied to all the children in the population and we estimate the relative reduction in mean caries probability compared to a hypothetical situation where none of the children had a sealant.

Scenario 2: when dental sealants are applied to all children while all other variables are unchanged and compared to the mean caries probability observed in the sample

Scenario 3: if all children were from low-income households and sealants were applied to all of them compared to none of them

Scenario 4: if all children were from high-income households and sealants were applied to all of them compared to none of them

TABLE 7.7: Relative reduction in mean probability of dental caries under different scenarios (using Table 7.6 estimates)

Scenario	**Description**	**Relative Reduction in Mean Probability of Dental Caries**
1	When sealants applied to all children compared to no sealants at mean values for other variables	=(0.498-0.198)/0.498 =60%
2	When sealants applied to all children compared to observed data	=(0.445-0.21)/0.445 =52%
3	If all children were low-income and sealants applied to all compared to none	=(.563-.246)/.563 =56%
4	If all children were high-income and sealants applied to all compared to none	=(0.36-0.115)/0.36 =68%

Our calculations show that there is varying degree of relative decrease in predicted mean probability of caries in children in the four scenarios mentioned. For an average child in this population, sealant application may decrease the mean probability of any caries by 60%. However, if all variables are at their observed values in the population, then the decrease predicted as a result of sealant application is about 52%. The third and fourth scenarios estimate whether application of sealants has a different effect depending on household income. Our model predictions show that the relative decrease in predicted mean probability of dental caries will be 56% for low-income children, but a surprising 68% for high-income children. These results may be explained by the fact that low-income children have other factors in their environment or diet that add to their susceptibility to caries. However, if high-income children receive a preventive service that includes a sealant, then the protective effect of sealants is more marked. Hence, we see a more dramatic difference in caries probability in high-income children who receive caries than low-income children who receive caries when they are compared to their respective counterparts with no sealants.

7.2 COST IMPLICATIONS OF SEALANT APPLICATION

From a clinical point of view, one could compare the difference in the quality of a tooth that is in its natural healthy form and one that has been compromised by dental caries. Measures such as Quality of Life Years (QALYs) are used in cost utility analysis to capture these differences in health states (Brennan 2006; Testa 1996). The QALY approach makes two key assumptions about societal values and health benefits. First, that the societal value of a health service is equal to the sum of health benefits it produces and second, that the health benefit for each individual is the sum of the gain in utility in all the life years that person enjoys with these benefits. These measures are based on indices that have been developed by various sources. Some examples of QALYs used in assessment of oral health quality of life (OHRQOL) include Oral Health Impact Profile, OH-Qol UK, and Oral Impacts on Daily Performances (Oscarson 2007; Allen 2003). Such measures take into account physical, psychological and social aspects of oral health. They are usually based on personal beliefs and perceptions but may also include clinical assessments (Testa 1996). However, there is little consensus on which system or index to use and very few studies exist that compare different measures of QALYs for accuracy. One such effort that looked at over 50 studies in pediatric care found a great variation in the methods and no standardization in the methodology of QALYs in cost utility analyses (Griebsch 2005).

Cost utility analysis is good for comparing different treatments from a clinical and social point of view but it does little in making a clear argument for allocation of resources at the budgetary level where preventive healthcare costs compete with costs in other areas such as education or transportation (Nord 1999).[59] Cost-benefit analysis that calculates the benefits of programs in monetary value, while unable to capture complex issues related to distribution and severity of disease is helpful in making such comparisons from a policy perspective.

Having shown the relative decrease in dental caries in different scenarios, we can start understanding the economic impact of sealant application in an underserved population. Deery (1999) reviewed literature, spanning over 30 years, on the economic evaluation of pit-and-fissure sealants and found that most studies compare sealant outcomes to restorations for the purpose of estimating cost-benefit. The principle approach in this case is to compare the cost of placing a sealant in a child with the cost of a restoration times the number of caries expected to be prevented by such application (Klein 1985, Morgan 1998). The basis of this calculation is that sealant application prevents caries in teeth. If a tooth gets caries then it needs to be restored, which usually involves using a material to fill in the cavity that has been caused by bacterial action – hence the term “filling.”

In most economic evaluations the benefit of sealants is measured in dollar terms by assigning a dollar value to the number of caries that sealant application prevent.[60] Thus, if in a sample of *x* children, *y* number of caries are prevented if everyone gets a sealant, then the cost-benefit is calculated by comparing cost, *w*, of putting in sealants in *x* children with the cost of restoration, *z*, multiplied by the number *y* which represents the

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[59] Nord describes three levels at which economic evaluations may take place: budgetary, admission, or bed-side levels.

[60] Deery differentiates cost-benefit analysis and cost-effectiveness, cost-minimization or cost-utility analysis on the basis of outcomes measured. Cost-benefit analysis, according to Deery, is used when outcomes of alternative s are different and the denominator is dollar value. He gives the example of fissure sealant versus amalgam restorations. Cost-effectiveness and cost-minimization are used when the outcome is the same with different alternatives to achieve it. Cost-utility is an extension of cost-benefit analysis.

decrease in the number of children who would have had needed restoration as a result of caries that occurred without the intervention.

So mathematically we compare

$$\sum w\,x \;=\; \sum z\,y$$

at the population level, to estimate the cost-benefit of sealant application while keeping other variables constant.

We can derive x and y from our data. x will be the number of children who will get sealant application and y will be the number of children in whom caries could be prevented by applying sealants to all children as compared to the observed data. We are making several assumptions here that make our estimation of cost of restorations quite conservative. First, we are assuming that the child with any caries will have only one tooth restoration and not multiple ones. That is not usually the case and the cost of restorations increases with increased number of surfaces and teeth involved. Second, we also assume that the restoration is a single-surface, simple restoration and not a more complicated and many times more expensive restoration that involves multiple surfaces or even crown or tooth replacement. Third, we are assuming that a healthy tooth and a restored tooth are equal in value, which is not the case in the real world. A restored tooth has lost some of the healthy tooth tissue and affects the long-term retention of a tooth. However, assigning cost to these differences is beyond the scope of our data.[61]

[61] There have been some attempts to develop Oral Health Quality of Life Year measures to capture differences between healthy and diseased teeth. Most of these quality of life measures are based on elaborate indices such as the Oral Health Impact Profile (Slade 1998) and Oral Impact on Daily Performance (Pearson 2007).

7.2.1 Cost Estimation for Sealants and Restorations

As far as the actual cost for services such as pit-and-fissure sealants and tooth restorations, it varies from state to state and even within communities (Griffin 2002). There are two main sources to estimate the range of costs for these services. We can take the numbers calculated by other sealant programs or we can use the dental fee schedule published by the American Dental Association (ADA 2006). The ADA fee schedule gives an average rate for several procedures and services that are reported by dental offices in a certain region. Thus, it is a fairly reliable estimate of what an average dental visit or dental procedure will cost in a certain region of the United States (ADA 2007).

Griffin et al (2002) use the one-time sealant application of $27 based on ADA 1999 survey of fees ($35 in 2005 dollars using CPI for dental services). [62] They also calculate the ratio of restoration costs to sealant costs to be 2.73. From this calculation, the restoration cost of a tooth will be about $73.71 in 1999 dollars (approximately $95.82 in 2005 dollars). The 2.73 ratio of cost of sealants and restorations is close to the ratio of 3 seen in Resource-Based Relative Value Scale (RBRVS) or Relative Value Unit[63] used by the Centers for Medicare and Medicaid Services as measure of the work involved for different procedures for provider reimbursement. A dental sealant application on a single tooth has an RVU of 0.5 as compared to one-surface amalgam restoration of RVU 1.5 and resin-based restoration 2.0 (Washington State Health Care Authority 2006).[64] Thus, the ratio of cost for single tooth sealant application versus one-surface restoration is anywhere from 3 to 4 according to the RVU scale.

[62] We use consumer price index for dental services from Bureau of Labor Statistics data at www.bls.gov. For general consumer price index calculations a useful site is the Official and Williamson online calculator. http://www.measuringworth.com/calculators/uscompare.

[63] RVU or Resource-based Relative Value Scale (RVRBS) for Medicare are based on three types of patient services: physician work, practice expense, malpractice expense.

[64] There are two main types of restorations, commonly called "fillings." Amalgam (or silver) restorations usually cost less than resin-based (or other composite material) restorations (Christensen GJ. Amalgam vs. composite resin: 1998. JADA;129(12): 1757-1759).

Dasanayake (2003) used dental claims data of 5- to 7-year-olds in Alabama Medicaid program to calculate a charge of about $94.10 for those who used both sealant and restorative treatment of which sealant cost was $34.02 and restoration cost was $60.08. In their cohort of over 7,000 children restorative treatment was almost 4 times more likely in those children without sealants as compared to those with sealants.

Slightly more than half of the expenses on dental services are paid out-of-pocket as shown by an analysis of the Medical Expenditure Panel Survey data (Brown 2004). The rest of the major portion is paid by private health insurance.[65] Most economic studies use clinic fees for such procedures to measure the cost. The market price ought to be a good measure of the value of such a service because presumably it takes into account the supply and demand for such services in the community. This approach has been used by Griffin (2002), Brown (1998) and Morgan (1998).

The second approach of estimating costs will be to just focus on the actual cost of providing these services as part of a community or school-based program and use that as a measure of the cost of expanding these services through a program at a population or community-level. Calderone (1983), Werner (2000), and Klein (1985) calculate the actual costs for their programs. One of the most comprehensive calculations in this regard have been done by Calderone and Mueller (1983) using data from a school-based pit-and-fissure sealant program in New Mexico. The program employed portable equipment and dental hygienist and dental assistant teams for applying sealants to over 3,000 children. Calderone used actual time spent for applying sealants, total number of hours by dental professionals, amount of travel time charged, total salaries and benefits of team members, gas and maintenance changes, amortized equipment costs, and cost of

[65] Between 1996-2000, Medicaid only paid 2.8% of the total estimated 56 billion dental expenditure per year. (Brown 2004)

supplies. They found the cost of sealant application only $7.41 per child. Using the average consumer price index for dental services this comes to about $14.53 in 2005 dollar value.[66] But prices of dental services have increased more rapidly than the basket of goods and services included in the overall CPI. We, therefore, use CPI for dental services from Bureau of Labor Statistics' data with base period between 1982-84, to find an increase in dental service prices between 1983 and 2005 to be about 324%.[67] So the cost per child from the Calderone program comes to $ 25.34.

Werner et al (2000) report the cost-effectiveness of a school-based sealant program but they simply calculate the total cost of providing sealants to children in their program and divide it by the number of tooth surfaces estimated to be prevented from caries. They calculated the dollar amount per saved surface to be in the range of $42-$65.

While several economic evaluations have found sealant programs to be cost-effective (Klein 1985, Morgan 1997; Niessen 1984) when applied across the board to all children in underserved populations, many find mixed results. Cost-effectiveness depends on the risk of caries and on income levels (Leverett 1983, Deery 1999). Weintraub et al (2001) used Medicaid fee schedule of 1992 and studied the dental expenditure of 15,000 children in North Carolina Medicaid program. They used 1992 Medicaid fee schedule of $11.60 per sealant and $18.57 for one-surface amalgam restoration. They concluded that enough savings did not accrue to the Medicaid program to warrant placing sealants on all Medicaid-eligible children. Griffin et al (2002) found that giving sealants to all children is less costly than not giving sealants to anyone and even less costly than targeted sealant delivery programs in high risk populations. In relatively low risk populations, giving sealants to all children was more costly than targeted sealant applications but still less

[66] Calculated using online calculator developed by Officer and Williamson, 2007. Available at http://www.measuringworth.com/uscompare/.
[67] We used Series ID: CUUR0000SEMC02 for CPI-All Urban Consumers calculations of dental services. Available at http://data.bls.gov/cgi-bin/dsrv. Accessed July 3, 2007

costly than not giving sealants to anyone. However, this study was based on data from several sources and not based on a low-income underserved population where continuity of care is a significant problem.

Usually two teeth are sealed in a regular preventive dental visit. For children at or around the age of 6 years, two molars are sealed just as they erupt (these molars are also called 6-year molars). The second set of molars erupts around the age of 12 years and that is the time that these 12-year molars are sealed. If a child does not have any sealants then all four molars are sealed at the same time. Most school-based programs put sealants for second graders, when they are around 6 years old and fifth or sixth graders, when they are about 12 years old. In most cases, the teeth of those who had received a sealant in the previous year (say third graders or seventh graders) are examined to make sure that the sealants have been retained. Our analysis did not differentiate as to the number of teeth sealed in a child. We only counted any sealant to be a proxy for preventive care. It is therefore useful to have a cost calculation that is on the basis of per child rather than per surface (the latter being the case with most cost evaluation studies).

The ADA 2005 survey of dental fee (West South Central Region) estimates the cost of single sealant application as $34.30 (median $34) and one surface restoration as $84.33 (median $81). There are few examples where actual cost of sealant application in a real world program is calculated. We use the results of the study in New Mexico by Calderone (1983) where sealants were applied through dental hygienists using portable dental equipment in school settings. They covered 3,272 children and the cost to the program was $1.40 per sealant per tooth and $7.49 per child in 1983 dollars ($25.34 in 2005 dollars using CPI for dental services). Since we do not have as detailed data as used by Calderone in their calculation of costs for sealants, we use the Calderone calculations to estimate sealant costs per child in our sample assuming that the costs would not be very different in underserved areas in New Mexico and Texas. We use CPI for dental services to equate the cost calculated by Calderone in 2005 dollar value for comparison with restoration costs with the most recent ADA data available.

7.2.2 Cost-benefit Analysis

A cost-benefit analysis that compares merely sealant costs to restoration costs is based on an underlying assumption that a healthy tooth is equal in value to a restored tooth. First of all a restoration is an invasive procedure that can scare children and affect their future willingness for dental utilization. Restoration procedure also inevitably results in loss of healthy tooth tissue which is never replaced and may, after repeated restorations, lead to loss of tooth. Sealant application on the other hand maintains a tooth in its natural healthy state. While not ideal, in the absence of better data or more accurate alternative, a comparison between the cost of sealant provision and the cost of restorations of preventable caries at least gives policy makers an economic rationale for providing sealants as preventive care in underserved populations. It also provides a basis for making tough decisions about who gets what service and at what cost (Kernick 1998).

We make certain assumptions in order to estimate the cost-benefit of sealant application in our study population. Sealants have a certain retention rate which necessitates re-application after a few years and restorations are also repeated after a few years almost throughout life (Deery 2005). Sealants may be retained for up to 10 years although the rate of loss increases with time (Ripa 1993; Ahovuo-Saloranta 2004). We assume that there are no significant differences in the retention of sealants and restorations. This is based on some preliminary calculations by Griffin (2002) which showed the two rates to be very similar. We are also not taking into account such costs as the time parents or teachers have to take off their regular jobs to get these dental services for the children. This is one of the major advantages of school-based sealants program which makes them convenient and cost-beneficial compared to a visit to the dentist, whether for sealant application or for restoration services.

The pain and discomfort caused by carious teeth is one of the most common reasons for children missing school (CDC 2007). The cost of missing school and the resulting loss of economic productivity of their parents, who either stay home or make arrangements for child care, are also not included in our calculations. Many restorations end up later in life to require crown replacement or tooth replacement, the cost for any of these procedures being in hundreds of dollars but we do not have data to associate the cost of such consequences.

We use predicted decrease as shown in Tables 7.7 to estimate cost differences in applying sealants to all or selected group of children in our population versus the benefit of preventing treatment for dental caries that are reduced as a result of sealant application. For convenience of calculations we make these calculations at an individual child's level, which can be extrapolated for larger populations with similar socioeconomic and demographic features. While dental sealant fee are over $35 per child in a dentist's office, they are around $25 per child in a school-based or school-linked program. One of the reason for this difference is that the cost of application of sealants depends on the location (dentist office versus school clinic) and the dental professional conducting the procedure. Most school-based programs use dental hygienists to provide dental sealants, which reduces the cost of such application per child as compared to receiving these services in a dental office. School-based sealant programs, therefore, provide a cost-saving by using dental hygienists for sealant application.

Studies have shown little difference in the retention rates of sealants that are applied by dental hygienists and dentists. For example, in a 10-year, retrospective cohort study to evaluate the effectiveness of dental sealants placed by dentists, dental hygienists and dental assisstants, the registered dental hygienists showed better success rates than the other professionals (Folke 2004). On the other hand, most restorations take place in a dentist's office and to calculate the cost of restorations it will be realistic to use the ADA survey of dental fees.[68]

Similar to the work of Griffin (2002), from a policy perspective, we would like to estimate the cost-benefit of providing sealants to all school-children or only to targeted high-risk children and compare both of these with the option of providing no sealants. The cost of application of sealants per child based on Calderone's calculations is $25.34 (in 2005 dollars). Based on Table 7.7, we have shown that there is a 52% decrease in the probability of caries in our observed sample with the application of a sealant. Thus application of a sealant will on average save 52% of cost of restoration per child. The cost of restoration according to ADA schedule is $84.33 per surface. Thus the cost saving per child can be estimated as 52% less of the restoration cost, which comes to around $43.85 per child. This translates to a net benefit ratio of 0.73, which means that for every dollar spent on preventive care by applying sealants to school children in our sample, $0.73 will be saved in cost of treating caries.

Table 7.8 also shows that if every student was given a voucher to get a sealant at a private clinic at the prevailing rates, even then the net benefit ratio will be 0.28. That means that every dollar that is spent on prevention by providing dental sealants to children at the private clinic rate, $0.28 will be saved in restoration costs in addition to the maintenance of a healthy tooth in these children.

A more restrictive program for providing school-based sealants will be one that only focuses on low-income children. We use an annual income of $25,000 as a cutoff

[68] There are also differences in rates of which type of material is used for restorations and who applies the sealants.

for identifying low-income households. Table 7.7 shows that the decrease in probability of caries in a child from low-income household is even higher (56%) than the average child in our sample. Hence, the cost saving of providing dental sealants to a low-income child in our sample will be about $47.22, as shown in Table 7.8. The net benefit ratio will therefore be 0.86, which means that for every dollar of prevention spent on a low-income child in our sample, we can expect a benefit of $0.86.

TABLE 7.8: Net benefit ratio of sealant application per child for single surface restoration

	Sealants in a private clinic	**Sealants for all in school-based program**	**Sealants for low-income**
cost of sealant per child	$34.30	$25.34	$25.34
cost of restoration per surface	$84.33	$84.33	$84.33
decrease in probability of caries	52%	52%	56%
cost saving per child	$43.85	$43.85	$47.22
net benefit ratio	0.28	0.76	0.86

Our outcome variable, *caries2,* in the estimated model is a binary variable that only measures whether a child in our sample had a dental caries on any tooth. As a result when we calculate the cost-benefit ratio in Table 7.8, we assume only a single surface restoration per child. However, that is not the usual case. In our sample, the average number of caries in those children that had any caries was 3.6.[69] Since sealant application in a child is likely to save 3.6 restorations in our sample, the cost-benefit ratio will be even more impressive when this is taken into account. Table 7.9 shows that for every

[69] The average number of caries in our sample is not very different from the average number in the larger number of students who were examined by the teledentistry project. The average number of caries per child in the screening data was 3.06.

dollar spent for providing sealants to a child in a sample like ours, anywhere from $5.30 to $5.78 will be saved.[70]

TABLE 7.9: Net benefit ratio of sealant application per child

	Sealants in a private clinic	Sealants for all	Sealants for low-income
cost of sealant per child	$34.30	$25.34	$25.34
cost of restoration per surface	$309.96	$309.96	$306.96
decrease in probability of caries	52%	52%	56%
cost saving per child	$159.62	$159.62	$171.90
net benefit ratio	3.65	5.30	5.78

It is pertinent to reiterate that we are using the strictest criteria to compare cost of sealants to cost of restorations. If sealants are applied at the 6-year molar and 12-year molar eruption stage and regularly monitored for ensuring retention then in most cases we will be ensuring a healthy tooth in the adult dentition. Teeth which survive without being affected by caries during the formative years of childhood and adolescent then develop enough strength to resist carious lesions throughout most of the adult life. On the other hand, a tooth that has been restored has been compromised. It is likely to undergo several more restorations and eventual replacement of crown or root canal procedures. The average life of a restoration was assumed to be around 9 years by Griffin (2002) in her calculations, which means a much higher life-time costs for restorations compared to dental sealant applications.

[70] This saving is shown despite the fact that we did not include cost of transportation and wait at the clinic for getting sealants or restorations outside the school premises, which would add to the cost of $34.30 and $84.33 derived from the ADA survey of fee for these procedures in a dental clinic.

The economic benefits of a preventive sealant program will be significant in populations such as ours. Almost 82% of the Lyford School District population of children is classified as economically disadvantaged.[71] In our sample about 70% of the children are low income according to our definition of annual income of below $25000.[72] But the impact of a policy for introducing or supporting school-based sealant programs must be considered in the perspective of the number of children in rural underserved populations. About 1.8 million children live in the counties bordering the US-Mexico border and about 0.5 million of these children live below poverty.[73]

7.3 STRENGTHS AND LIMITATIONS OF OUR DATA

In a review of literature on the economic evaluation of sealants, Deery states that the evidence "is contradictory and inconclusive." He also identifies the need for sealant cost effectiveness based on 'real world' situations "rather than extrapolations from clinical trials." Our data is unique in that the clinical data was collected as a service delivery project and not part of a research project or clinical trial. Also, our survey collecting socioeconomic and demographic information was conducted two years after the clinical examinations. This should minimize the unavoidable "researcher bias" that may influence data collection and analysis in projects where the same people who are conducting the clinical examinations also conduct evaluation of the services (Finlay

[71] The number of economically disadvantaged students is determined by averaging the best six months enrollment in the national school lunch program or free or reduced-price lunch for the preceding school year.

[72] We do not take family size into a our criterion although the school free lunch programs for economically disadvantaged children take this factor into account, so that children from households with >$25,000 annual income may also be included as economically disadvantaged.

[73] The 37% poverty rate for Hispanic children along the border is twice the national child poverty rate of 17% (Annie Casie Foundation 2005)

2002). There have also been few studies, if any, that have analyzed the economics of dental sealant programs in Hispanic populations in rural areas.

We do recognize the limitations in our data because of the gap in the collection of clinical dental data through examinations and the socioeconomic and demographic data collected through surveys. We assume that socioeconomic and demographic factors for households have not changed over this time period. However, during our interviews with school administrators and parents at Lyford School, no obvious factor was identified that would make this assumption unreasonable. As a result of matching data sets that were collected two years apart, we presumably lost a number of children from our sample for which both clinical and socioeconomic information was available. This reduced the size of the sample we had to work with. Another factor that reduced the number of matched observations between the two data sets could have been the fact that the surveys were filled in by hand and mistakes could have been made either by parents in spelling last names or by us in translating these handwritten names and dates of birth. The names and dates of birth of those who matched were re-checked by the school authorities at Lyford for accuracy. While this could be a source of inaccuracy in the data we used chi-square tests to check if the matched sample's characteristics were systematically and significantly different from survey respondents. We found no statistically significant difference between the two.

We also realize that our data is derived from a particular underserved Hispanic population in south Texas. Since we collected primary data under resource constraints, some of the information we collected was not detailed enough to help us analyze some other factors such as the role of Medicaid or SCHIP in detail. For instance, although we asked people if they were eligible for Medicaid and SCHIP, we did not know how long they have been eligible. We also did not have information about nutritional habits and other behaviors that may affect either dental caries or sealant applications. These results can only be generalized to other such underserved Hispanic populations with some reservations. Nonetheless our study provides a window into the complex factors affecting dental caries in underserved populations and attempts to fill in a small part of a larger picture. Further research will be needed to test the generalizability of these results in other underserved populations.

We also do not compare sealant application as a preventive strategy with other preventive strategies such as water fluoridation or fluoride applications. This was not only beyond the scope of our research but given that 90% of caries occur on occlusal surfaces of teeth and that fluorides are mainly effective for preventing smooth surface caries, study of sealants as the preventive strategy in underserved populations is a more policy relevant topic.

7.4 POLICY ISSUES

Dental caries is a chronic disease that affects children and adolescents in underserved populations at significantly higher rates than others. It is also a disease about which we know much more now than we did a few decades ago. The scientific advancement in our understanding of effective preventive strategies for dental caries should inform public policy to fight what has become the most prevalent chronic disease of childhood in America. Our research attempted to answer two questions: 1) Are dental sealants effective in reducing dental caries in an underserved population?; 2) Would a school-based dental sealant program be a cost-beneficial strategy?

Our analysis provides strong evidence of sealant effectiveness in preventing dental caries. Pit and fissure sealants are aimed at protecting tooth surfaces where 90% of dental caries occur (Ripa 1993). According to the Surgeon General's Report 2000, sealed tooth surfaces will have complete protection from caries as long as the sealants are retained (US DHHS 2000). Our analysis shows a 52-68% reduction in children with any caries in our underserved population. This is comparable to the effectiveness of sealants found in other studies as well (CDC 2001, Truman 2002). Our results were empirically robust and statistically significant. Hence, our analysis supports sealants as an effective strategy for caries prevention. We also find, using cost data from other school-based sealant programs that providing sealants to school children is also a cost-beneficial strategy. We perform a conservative estimate of costs and benefits and still find school-based sealant applications to be cost beneficial if provided to all the children in our study population. Our data also show that the savings from prevented caries will be greater than the cost of providing sealants whether the program was offered to all student or only to targeted low-income children in our population.

The next policy question that follows from this result is what would be an effective and efficient way to provide sealants to children in underserved populations. There are several different ways to provide sealant applications and it was beyond the scope of our data to compare different models of delivery. It is surely a future research recommendation. We use cost estimates from secondary sources to simulate the cost-benefit of providing sealants through a school-based dental program similar to ones that are being implemented in a number of states in the United States, such as Ohio and Wisconsin. These programs are mainly delivered through dental hygienists who provide dental sealants in schools using portable equipment. We use the portable equipment school-sealant program as our model of delivery, but there are several other models that have been implemented in different parts of the country.

7.4.1 Different Models for Delivering School-based Dental Care

Although our data does not inform the debate regarding the different models of delivery of school-based services, it is relevant to briefly discuss these models as policy alternatives. School-based health clinics have been used for delivery of health services in underserved communities since 1970s. The first such clinic is reported in Dallas, Texas and in mid-1990s there were estimated to be about 600 school-based health clinics in the United States. In 2005, more than 1,000 such clinics were functioning in most of the states of America (Albert 2005). Most of these clinics are set up in urban areas where they provide essential primary care services ranging from health and nutrition education to basic laboratory and referral services. Dental services are provided in many health clinics primarily for prevention and screening (Albert 2005). The Department of Health and Human Services reported about 29 states having some school-based sealant programs (CDC 2005). However, all these programs together serve slightly less than 200,000 children a year, which is only 3% of the poor children in America (US DHHS 2005). Such low numbers are surprising from a public health perspective, especially when it has been shown that children in schools that have school-based sealant programs are far more likely to have sealants than students in schools without such program. For instance, in Ohio 57% of third grade students in schools with dental sealant programs had a sealant compared to only 28% of students at schools without sealant programs (CDC 2001).

7.4.2 Costs of Different Delivery Options

A joint project of Ohio Department of Health, Indian Health Services and Association of State and Territorial Dental Directors has developed a Safety Net Dental Clinic Manual that calculates average costs for setting up and running three different types of dental clinics: fixed, mobile, and portable.[74] The Manual gives detailed cost for equipment, operating expenses, and personnel. The start up cost for a portable clinic is only around $42,000 as compared to $400,000 and $560,000 for mobile and fixed clinics. In our cost-benefit analysis we have used the cost calculated from a portable equipment school-based clinic, which also has the lowest set-up and total costs in Table 10.

TABLE 7.10: Dental clinic costs for fixed, mobile and portable clinics

	Fixed	**Mobile**	**Portable**
Size	3-chair (1800 sq ft)	2-chair	2-chair
Patients Treated/Year	1000-1800	500-800	500-800
Visits/Year	3000-3400	1400-2000	1200-1800
Start-up Costs			
Remodeling ($131/sq ft)			
Construction($197/sq ft)	$354,600	$358,680	N/A
Large Equipment	$162,214	$19,100 Most equipment is built into unit	$18,375
Supplies, Instruments and Small Equipment	$45,728	$23,520	$23,520
Annual Operating Costs			
Staff	1	1	1
Dentists' Average Salary Director $130,000 Staff $98,000	$130,000	$98,000	$98,000
Dental Assistants' Average Salary $31,410	2 $62,820	2 $62,820	2 $62,820
Dental Hygienists' Average Salary $60,476	0.5 $30,238	N/A	N/A
Clerical/Receptionists' Average Salary $34,320	0	N/A	N/A
Utilities Average $8,500 to $11,700	$8,500	Varies $0 to $3,500	N/A

[74] Available at http://www.dentalclinicmanual.com/.

Rent or Mortgage Payment Average $28,900	$26,250	N/A	N/A
Dental Supplies $6,700/operatory	$20,100	$13,500	$13,500
Other (charts, office supplies, etc.) $2,300 to $4,600	$2,300	$2,300	$2,300
Total Start-Up Costs	$562,542	$401,300	$41,895
Total Annual Operating Costs	$280,208	$180,120	$176,620
Total First-Year Costs	$842,750	$581,420	$218,515
* Fixed locations may include a free-standing facility, community health center, hospital, school or other location. ** Cost is based on 2004 salaries in the Southwest and 2004 equipment/supply costs adjusted for inflation for 2007.			

Source: Safety Net Dental Clinic Manual (www.dentalclinicmanual.com/menu.html)

Setting up dental clinics in schools or setting up dental care as part of school health clinic services requires several prerequisites. The most important is the needs assessment of the community and a review of the health care infrastructure. Most school dental health programs would probably not be feasible in affluent communities or those with a well developed dental care infrastructure. However, in underserved populations school dental programs can play a pivotal role in providing the much needed preventive and screening services to school-age children. The other factor which is important in setting up school dental programs is the active participation of school administration which in turn is affected by the support of the parents or community members.

7.4.2.1 Fixed Dental Clinics

School-based fixed dental clinics usually work in affluent school districts or schools with large number of students in geographical vicinity but may not be suitable for schools in rural areas. Besides the availability of space for a physical clinic the more difficult problem is getting a dental professional dedicated to such a facility. The other major limitation of a fixed clinic is the availability of immense resources required for set-up and to make it work in a cost-effective manner. Where space and funds are available with a school district in rural area, a single-chair dental clinic may be set up as part of the school health clinic and the dentist or dental hygienist can visit a few days a week to provide necessary preventive care.

7.4.2.2 Teledentistry Clinics

An innovative modification of this concept employs information technology to address the problem of finding dental professionals in rural settings. Teledentistry is the use of computers and telecommunication to provide dental services through a dental hygienist while the dentist provides supervision from a distance electronically (Golder 2000). Teledentistry has been widely used in Europe (Cook 2002) with positive results but unfortunately has not moved beyond pilot projects in the United States (Clark 2000). The University of Southern California (Chang 2003) and Texas A&M University (Folke 2001) ran some of the successful programs in the United States. There have not been many economic studies to assess the cost-benefit of a teledentistry project in rural communities (Scuffham 2002).In the absence of such evidence, teledentistry remains an alternate to be considered in rural areas where there is severe shortage of dentists while the telecommunication infrastructure is well developed. The clinical effectiveness of teledentistry systems has been well-established through randomized controlled trials (Mandall 2005; Stephens 2002).

7.4.2.3 Mobile Dental Clinics

Delivery of dental services to school children can also be rendered through mobile clinics. The most popular format of such delivery has been that of mobile vans that may be fitted with all treatment and restorative equipment. These vans work well where location of schools is convenient to reach by roads and dental professionals are available to dedicate enough time to travel. There are several limitations to this mode of delivery: first, it requires time commitment by dental professionals because it includes travel time. Second, there is wear and tear of equipment used for dental equipment (Albert 2005). An informal survey of dental mobile vans on a public health dentistry listserve identified such services in California, Florida, Georgia, Iowa, Michigan, and Missouri. Limited mobile dental van programs have operated in Texas but none has expanded in any significant manner. Werner (2000) reported a mobile dental van operated by the University of Texas Health Sciences Center San Antonio. The Texas Department of Health also operated a mobile van in the border region some years ago. Most of these projects suffer from increased maintenance costs and lack of funding (Werner 2000). A successful mobile dental van program has been reported in Austin, run by St. David's Hospital. It provides school-based services in Austin area (Jackson 2007).

7.4.2.4 Portable Dental Equipment

Another way of delivering dental services without establishing fixed clinics is to use portable dental equipment that dental professionals carry with them. This method has the limitations of the type of services or dental procedures available to schools (Morreale 2003). On the other hand, because of the low expenditures involved in making it work, it is quite suitable for screening and sealant programs in states that allow auxiliaries to perform these functions without supervision. The State of Missouri provides portable dental equipment for dental hygienists and dental professionals who want to do outreach activities in their communities.[75] The portable equipment set consists of patient chair, dentist stool, light, air-compressor and portable dental unit. The equipment can be borrowed without a charge and can be carried around in a car.[76] Wisconsin also runs several school-based programs that use portable equipment. Another successful school-based sealant program that used portable equipment was used in New Mexico and results reported by Calderone and Mueller (1983). A team of dental hygienist and dental assistant carried portable equipment to schools and sealed the newly erupted permanent teeth. The project reported cost savings and effectiveness.

7.5 SCOPE OF DELIVERY

One issue that affects the cost-benefit and mode of delivery of school-based sealant programs depends on who provides these services. In most states where school-based dental sealant programs have been widely used, dental hygienists have played a key role in making these programs successful. However, in public health dentistry this scope of practice is a fairly contentious issue (Nolan 2003).

It is hard to think of a successful and cost-efficient strategy that relies solely on dentists to provide preventive dental care in school-based clinics. Not only is there a significant shortage of dentists in underserved areas but due to low reimbursement rates by Medicaid, the participation of dentists in Medicaid program for the poor is fairly low (Catalanotto 2006; Hughes 2005). Willacy County has only two dentists for a population

[75] http://www.dhss.mo.gov/oralhealth/PortableDentalEquip.html

[76] Personal communication with Director of a sealant program in Wisconsin. May 18, 2007.

of around 20,000 (TDH 2002). It is also reported that about a third of the counties in Texas have no dentist (CHASP 2003). According to one estimate there are only 3,500 pediatric dentists who specialize in treating young children (Nolan 2003). There is also a maldistribution of dentists between urban and rural areas (Knapp 2000). According to a study of availability and distribution of dentists in rural areas and health professional shortage areas (HPSA), Knapp and Hardwick (2000) found that over 50% (or 5.8 million) of rural HPSA-residents lived in ZIP code areas with no providers. Another study found more than 1,480 United States' communities that have dentist shortages, a number that has doubled since 1990. [77] According to this report it is estimated that more than 4,500 dentists are required to provide services to more than 31 million Americans living in dentist shortage areas (Kaiser Network 2003).

Given the workforce shortage of dentists in rural communities, it is not surprising that states and communities have looked at alternatives to fill in the gap of dental services. Providing school-based services through dental hygienists is a policy option that has been implemented in many states.[78] According to a detailed analysis of dental practice laws, about forty-four states allow dental hygienists to deliver complete preventive services including fluoride and sealant applications under the general supervision of a dentist (Nolan 2003). Five states (Alabama, Georgia, Hawaii, Louisiana, and Oklahoma) require direct supervision for even preventive services to be delivered by dental hygienists. The difference between direct supervision and general supervision is that in general supervision the dentist is not required to be on the treatment premises but the procedure has to be authorized by a dentist. Under direct supervision the dentist is

[77] According to ADA there are about 152,000 dentists in the United States, of which one-third are above the age of 55.

[78] The number of dental hygienists increased from 72,000 in 1990 to 120,000 in 2001. There are more than 260 accredited programs in the United States to train about 5,000 dental hygienists each year. Bureau of Health Professions, HRSA. http://bhpr.hrsa.gov/healthworkforce/reports/hygienists/dh1.htm

required to be on treatment premises while services are being provided. There are only a few states that allow autonomous practice for dental hygienists where dentist supervision is not required and the hygienist can provide preventive dental services independently. [79] Most states have certain specific locations or situations that allow unsupervised practice by dental hygienists. For example Washington allows dental hygienists to practice unsupervised in hospitals, nursing homes and school settings. So is the case in Nevada and Colorado for public health dental hygienists (Astroth 1998). Most dentists and dental associations, however, oppose independent dental hygiene practice (Adams 2004).

Whether dental hygienists are able to provide dental sealants without supervision of a dentist in school settings has a significant influence on the type of delivery model that may be implemented in a certain underserved area. In terms of effectiveness of sealant applications, dental hygienists consistently perform as good as dentists (Folke 2004), which supports the delegation of sealant delivery to them particularly in school settings.[80] More research and discussion is required to sort out the details of the scope of practice, particularly related to rural and underserved populations. If the scope-of-practice laws are not made more flexible to allow for unsupervised practice of dental hygienists in school-settings then options like teledentistry can address some of these concerns in a situation where dental professional shortages are a significant policy challenge and a reality.

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[79] There are ambiguities about how many states allow unsupervised dental hygienist practice. According to ADHA 19 states have some form of unsupervised practice in their laws. http://www.adha.org/news/archives/2005/012805-study.htm

[80] Dental professionals in Europe, with similar training as dental hygienists in the United States, are routinely used for preventive dental care in school-based programs and public health settings (Axelsson 1999).

Chapter 8 - Conclusion

Our study has attempted to add to our understanding of dental caries prevention in underserved populations. Dental caries is the most common disease of childhood and one that can be rather easily prevented. It is therefore essential that policy makers use evidence to promote policies that will help in reducing the burden of this disease in children at the highest risk. Effective preventive policies, if implemented successfully, can almost eradicate dental caries from children and also drastically reduce dental problems in future adult populations.

We collected socioeconomic and demographic data through written surveys from parents of school children at Lyford Consolidated Independent School District in Willacy County. The surveys were both in English and Spanish and we got a 60% response to our survey. The survey data was then matched with dental examination data collected from a teledentistry project. We assumed that socioeconomic and demographic characteristics of households had not changed significantly during the time period between the clinical examinations and the survey. To check that there was no systematic selection bias in those who were in our matched sample and those who did not make it into this sample, we compared our matched sample with survey dataset and with dental examination dataset. No statistically significant difference between the two were observed except for the percentage of children in the matched dataset with longer stay in Willacy County was higher than in the survey dataset. However, as long as no selection bias exists on the basis of the dependent variables, the results of our data analysis would not be affected.

Our data analysis involved an econometric model to study the impact of various factors including dental sealants on the presence of dental caries in this quasi-experimental research design. It may be also described as a retrospective cohort study where we assumed dental sealant application to be a proxy for past preventive care and compared those with and without dental caries. Only 19% of children in our matched sample had any sealant and almost 43% had at least one dental caries. Of those who did not have sealants almost half (49%) had caries while of those with any sealant only 19% had any caries. Thus 80% of those with any sealant had no caries in their teeth at the time of examination. We also found that while half (48%) of those from low income households (ie, annual income <$25,000) had caries, only a third (34%) of those in higher income bracket had any caries. Overall, about 69% of children in our sample belonged to low income households.

We had two significant challenges in our model estimation. First, that most of our variables were binary or categorical thus creating possible identification issues. Second, there was potential endogeneity in our dental caries model. We used age as a continuous variable to address the identification concern and used multivariate probit models to test for endogeneity in a three equation model. The multivariate probit model uses Geweke-Hajivassiliou-Keane (GHK) simulator to generate correlations among error terms and structural and reduced form equations. Tests for endogeneity showed that the hypothesis of no endogeneity in our model could not be rejected, thus satisfying us that the estimated coefficients of a univariate model will not be biased and inconsistent. We chose univariate models for estimation because they impose relatively less limiting assumptions on the model.

The estimation results showed a strong and robust preventive effect of dental sealants on dental caries in our sample. We used OLS, logit, probit, and logistic regressions to confirm the results and obtained similar findings. Sealant application caused a significant decrease in the probability of dental caries in a typical child in our sample. We also used our fitted model to simulate the effect of providing sealants to all children in our sample and found that there will be a 52% decrease in the mean probability of caries in our sample when all the children are at their observed values for all other variables.

Our estimation results also showed statistically significant decrease in the probability of dental caries due to household income level when all other variables are kept constant. For those in the group with annual income below $25,000, the probability of caries was higher than in those with household incomes above $25,000. Other factors that also had statistically significant effect on decreasing dental caries included parent's health insurance status. Children of parents who had health insurance had less likelihood of dental caries than those whose parents did not have health insurance.

We also performed separate estimation of dental visit frequency in our sample. We wanted to study the socioeconomic, demographic and dental health factors that may affect the last dental visit of a child. Our analysis showed that neither the presence or absence of dental caries nor of dental sealants has any statistically significant effect on the probability that the child had a dental visit in the previous one year. However, our estimation showed that child's dental coverage status had a positive impact on frequency of dental visits. Similarly, children who had lived in the county for more than five years also had a higher probability of having had a dental visit in the last one year.

Finally, we used the results of our estimation and prediction models to compare the cost and benefits of providing dental sealants to children in our sample. We used the cost of sealants from two different sources: first, from the average cost of sealant application in a clinic as reported by the American Dental Association each year, and second, from a school-based portable equipment sealant program in New Mexico the results of which had been published in a peer-reviewed journal. We used all monetary values in 2005 dollars using consumer price index for dental services where needed. Our calculations showed that providing sealants to all children or only children from low-income households through a school-based program will be cost-beneficial when compared to the decrease in probability of caries and the resulting prevention of restoration costs. For every dollar spent on providing sealants through school-based programs, anywhere from $0.76 to about $5.78 are saved in treatment costs. In addition, such preventive care leaves the tooth uncompromised for a long and healthy life in the long run.

Our study provides useful results regarding strategies to prevent dental caries in an underserved population in south Texas. It clearly recommends a policy to provide dental sealants to children through school-based programs. We discuss other possible models of delivery of sealants to children in schools, including using mobile dental vans or even fixed dental clinics. The most innovative model that we discuss is that of using information technology to provide dental care through a dental hygienist model. This is called teledentistry and is a mode of delivery widely used in Europe. However, it was beyond the scope of our data to compare these different models of delivery.

There are some limitations of our data and our study that need to be mentioned. We have used a retrospective cohort study to look at the effect of dental sealants on dental caries in children. We have no way to find out the duration of the sealant application prior to the dental examination. We also only differentiate between those that have any caries and those with no caries. We do not count the number of caries to measure the severity of disease in different children. We also do not take into account how many teeth have sealants in a child. All these assumptions only make our estimate of protection by sealants to be conservative. Ideally we would have liked to conduct a prospective cohort study where we could have examined the children at a certain time and then applied sealants. Then after a certain period of time we would have re-examined them and seen how many had caries. Unfortunately time and money did not allow us the luxury to conduct such a study and we use data from two different examinations which were two years apart. We assume that the Sociodemographic and economic factors remain unchanged during this time period. These limitations may affect the generalizability of our results to other underserved Hispanic populations but given the dearth of such studies in Hispanic populations, our study still adds to our understanding of preventive oral health in such populations.

We consider our study to be a first step in a larger research program that needs to continue to understand the factors causing disparities in health in underserved populations. Future research may involve repeating such evaluations in other underserved populations to test the generalizability of some of the findings of our study. From a policy perspective, it would also be useful to compare different models of delivery of sealants. Better cost and price data for different services calculated from actual projects will be very helpful in conducting cost-benefit analysis of school-based sealant programs in different regions of the United States. Further research is also needed to evaluate the effect of different scope of practice laws and their impact on improving access to dental care for the poor. Currently many states are deliberating the pros and cons of relaxing strict scope of practice laws and addressing the workforce shortage in rural areas. Several innovative models have been piloted in different parts of the country but more scientific evaluation is needed to provide policy makers with better information to make these difficult decisions. While there have been some studies that focused on dental utilization in Medicaid eligible children, further research is needed to understand barriers to Medicaid use by underserved Hispanic populations. A comparison of rural and urban underserved Hispanic populations would also be a useful research project that will parse out the effects of race, rural setting and being part of an underserved population. Research on the cost-benefit of such innovative interventions as teledentistry will also be helpful additions to the knowledge base regarding the challenge of providing quality oral health services in rural and underserved populations.

The primary aim of our research was to understand from a policy perspective the impact of preventive dental care such as dental sealants on reducing the incidence of dental caries in underserved populations. Relying on primary data, we had to adjust our research strategy and make assumptions, according to the quality and availability of data we had. We were able to answer the two questions we had started with: are dental sealants part of an effective prevention strategy for dental caries in underserved populations? are they cost-beneficial? Further research is needed to answer some of the questions that have been raised as a result of this analysis. For instance, are these results replicable in other underserved populations or what are the most effective models for delivery of sealants. Our results strongly recommend the promotion of sealants in school children in underserved populations and show a significant drop in dental caries if such a policy is adopted. We hope our work will help to inform the debate on the provision of better preventive services to children who are least likely to get these services on their own.

APPENDIX 2.A : Search results from the AHRQ/NLM bibliography

The search terms we use for the AHRQ/NLM bibliography to look for similar studies in the literature:

search term	number of studies	examples of studies included in the search
sealant	47	Deery 1995; Geiger 2000; Hatibovic-Koffman 1998; Mertz-Fairhurst 1986; Bader 1987; Bohannan 1984; Bravo 1997; Cooney 1994; Ismail 1995; Morgan 1998; Odlum 1991; Ripa 1991; Rozier 1995; Songpaisan 1995; Weintraub 1993; Werner 2000; Songpaisan 1994; Carlsson 1997; Llodra 1993; Bravo 1996; de Rego 1996; NIH 1984; Ripa 1993; Rock 1996; Selwiitz 1995; Simonsen 1996; Winkler 1996; Whyte 1987; 1996; Albert 1999; Stephen 1990; Sterrit 1994; Tinanoff 1995;
sealant program	3	Ismail 1989, Kumar 1997, Werner 2000
Texas	0	
Hispanic	1	Ramos-Gomez , 1999
Mexican	0	
Latino	0	
minority	0	
minorities	0	
underserved	1	Warren 2000
Texas	0	
border	0	
economic/ economic analysis	11	Birch 1996; Lalloo 1999; Morgan 1998; Petersson 1994; Radford 2000; Slade 1996; Swedberg 1999; Thomson 2000; Tickle 1999; White 1989; Morgan 1998

Studies on School-based Sealant programs in the AHRQ/NLM bibliography

Author	Journal	Title	
Ismail AI	J Public Health Dent 1989	An evaluation of the Saskatchewan pit and fissure sealant program: a longitudinal followup.	

Kumar JV	J Public Health Manag Pract 1997	Evaluation of a school-based sealant program in New York State.	
Werner CW	ASDC J Dent Child 2000	Cost-effectiveness study of a school-based sealant program.	

APPENDIX 4.A : Survey instrument in English and Spanish

<u>Survey for Telehealth Project at Lyford ISD</u>

Instructions: Please fill out as many fields as possible. Give estimated numbers where you are not sure. The information you provide will be kept totally confidential and will not be released to anyone without consent from you except Dr. Lars Folke and Dr. Anjum Khurshid of the project. Your responses will be very important in improving the services delivered through telehealth and also in evaluating the economic benefits of the project. Please return the completed forms to the Lyford CISD school office.

1	Your name	
2	Contact information (address or phone number)	
3	Name of student at Lyford CISD	
4	What is the date of birth of the student (your child)?	
5	What is your relationship with the student?	☐ father/mother ☐ grandfather/mother ☐ relative ☐ Other ________________
6	Do you have health insurance for yourself?	☐ Yes ☐ No
7	Do you have dental insurance for yourself?	☐ Yes ☐ No
8	Does your child/children have dental insurance?	☐ Yes ☐ No
9	Does your child/children have health insurance?	☐ Yes ☐ No
10	Do you know how you can be eligible for any state or federal health plan such as Medicaid or SCHIP?	☐ Yes ☐ No ☐ Don’t know
11	Is your child/children eligible for Medicaid or a State Children Health Insurance Program (SCHIP)?	☐ Yes ☐ No ☐ Don’t know
12	If yes, how often have you used Medicaid or SCHIP during last 12 months?	☐ 0 ☐ 1-5 ☐ 6-10 ☐ more than 10
13	When was the last time you visited a dentist for yourself?	☐ 0- <6 months ☐ 6months - <1 year ☐ 1-5 years ☐ More than 5 years ☐ Never
14	When was the last time you visited a medical doctor (physician) for yourself?	☐ 0- <6 months ☐ 6months - <1 year ☐ 1-5 years ☐ More than 5 years ☐ Never
15	How far away is the dentist you visited?	in miles _____ in hours ______

16	How far away is the medical doctor (physician) you visited?	in miles _____ in hours ______
17	When was the last time you took your child to visit a dentist?	☐ 0- <6 months ☐ 6months - <1 year ☐ 1-5 years ☐ More than 5 years ☐ Never
18	When was the last time you took your child to visit a medical doctor?	☐ 0- <6 months ☐ 6months - <1 year ☐ 1-5 years ☐ More than 5 years ☐ Never
19	What transport did you use during your last visit to the dentist for your child?	☐ my car/truck ☐ friend's/relative's vehicle ☐ public transport ☐ other____________
20	How far away is the dentist you last visited for your child?	in miles _____ in hours ______
21	How far away is the medical doctor you last visited for your child?	in miles _____ in hours ______
22	How long do you usually wait to get appointment with a dentist?	☐ none ☐ 1-8 hours ☐ 2-5 days ☐ longer
23	How long do you usually wait to get appointment with a medical doctor?	☐ none ☐ 1-8 hours ☐ 2-5 days ☐ longer
24	How long do you usually wait in the dentist's office?	☐ 0-30 min ☐ 31 min-1 hour ☐ more than 1 hour
25	How long do you usually wait in a medical doctor's office?	☐ 0-30 min ☐ 31 min-1 hour ☐ more than 1 hour
26	How much time did you take off your work to take your child/children to a dentist? (if you have not done so, what do you think would be the time you would need?)	☐ 0- 1 hour ☐ 1 hour - <4 hour ☐ half - full day (4-8 hrs) ☐ more than 8 hrs
27	How much time did you take off your work to take your child/children to a physician or medical doctor? (if you have not done so, what do you think would be the time you would need?)	☐ 0- 1 hour ☐ 1 hour - <4 hour ☐ half - full day (4-8 hrs) ☐ more than 8 hrs
28	How many of your teeth have been taken out (extracted)?	☐ 0 ☐ 1-5 ☐ more than 5
29	How much did you pay in your last visit to a dentist for yourself?	☐ $0 ☐ $1-$20 ☐ $21- $50 ☐ $51- $100 ☐ don't know
30	Have you traveled across the border during last one year to get dental care:	
	• for yourself	☐ Yes ☐ No
	• for your child/children	☐ Yes ☐ No
31	Have you traveled across the border during last one year to get medical care:	
	• for yourself	☐ Yes ☐ No

	• for your child/children	☐ Yes ☐ No
32	Have you traveled across the border during last one year to get medicines:	
	• for yourself	☐ Yes ☐ No
	• for your child/children	☐ Yes ☐ No
33	Do you know about the telehealth project in your child's school where dental care is provided using information technology (computers and telecommunications)?	☐ Yes ☐ No
34	Are you satisfied that health services are being provided by the telehealth project in the school to your child/children?	☐ Highly satisfied ☐ Satisfied ☐ Unsatisfied ☐ Highly unsatisfied
35	Do you think that getting dental health services through school-based clinic helps you save money and time on your child's health needs?	☐ Yes ☐ No ☐ Don't know
36	Would you be satisfied if your child/children are provided oral health education and related nutritional counseling at Lyford CISD by a licensed dental hygienist?	☐ Yes ☐ No ☐ Don't know
37	Would you be satisfied if your child/children are regularly screened for oral diseases (cavities, gum diseases, etc) and provided preventive services at Lyford CISD by a licensed dental hygienist who is supervised by an affiliated local dentist through telehealth?	☐ Yes ☐ No ☐ Don't know
38	Would you be satisfied if your child/children are screened for chronic diseases (asthma, diabetes, obesity) at Lyford CISD by a licensed nurse?	☐ Yes ☐ No ☐ Don't know
39	Would you be satisfied if your child/children are screened for chronic diseases (asthma, diabetes, obesity) at Lyford CISD by a licensed nurse supervised by a physician through telehealth?	☐ Yes ☐ No ☐ Don't know
40	How long have you lived in Willacy County?	☐ 0- <6 months ☐ 6months - <1 year ☐ 1-5 years ☐ More than 5 years
41	What is your place (country) of birth? (*optional*)	☐ USA ☐ Mexico ☐ Latin America ☐ Other ______________________
42	What is the place of birth of your child/children? (*optional*)	☐ USA ☐ Mexico ☐ Latin America ☐ Other ______________________
43	What is your race? (*optional*)	☐ Hispanic ☐ White ☐ Black ☐ Other ______________________
44	What language(s) do you speak?	☐ Spanish only ☐ Spanish & English ☐ English only ☐ Other _______________

45	What kind of work do you do?	☐ Full-time ☐ Part-time ☐ Irregular ☐ Unemployed
46	How much do you earn per hour of work?	☐ less than $6 ☐ $6-$10 ☐ $11-$20 ☐ $21-$50 ☐ More than $50
47	What is the total income in a year of all the people living in your house?	☐ less than $10,000 ☐ $10,000 to $25,000☐ $25,001 – $50,0000 ☐ More than $50,000
48	What is your level of education?	☐ None ☐ 1-8th grade ☐ High school ☐ 2-yr college ☐ 4-yr college ☐ Postgraduate

Please return the completed forms to your child's school office or mail to Anjum Khurshid, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin, PO Box Y, Austin, TX 78713 or fax to 512-328-6269. Your participation is really appreciated. Thank you.

<u>**Encuesta para el Proyecto Telehealth en Lyford ISD**</u>

Instrucciones: Por favor llene todos los espacios posibles. Bríndenos una aproximación cuando no esté seguro(a). La información que nos brinde se mantendrá completamente confidencial y no se le permitirá ver a nadie más que a los investigadores sin su autorización. Favor de regresar estas formas a la oficina en la escuela de Lyford ISD.

1	¿Su Nombre?	
2	¿Domicilio y/o teléfono?	
3	¿Nombre del estudiante en Lyford CISD?	
4	¿Edad del estudiante?	
5	¿Cuál es su relación con el estudiante?	Padre/Madre Abuelo(a) Pariente Otro _____
6	¿Sabe usted como puede ser elegible para cualquier programa de salud federal o estatal como Medicaid o SCHIP?	☐ Si ☐ No
7	¿Son sus hijos elegibles para recibir Medicaid o el SCHIP?	☐ Si ☐ No
8	¿Si su respuesta a la pregunta anterior es afirmativa, diga cada cuando ha usado usted Medicaid o SCHIP durante los ultimos 12 meses?	☐ 0 ☐ 1-5 ☐ 6-10 ☐ >10
9	¿Tiene usted seguro de gastos médicos?	☐ Si ☐ No
10	¿Tiene usted seguro con póliza dental?	☐ Si ☐ No
11	¿Tienen sus hijos seguro con póliza dental?	☐ Si ☐ No
12	¿Tienen sus hijos seguro de gastos médicos?	☐ Si ☐ No
13	¿Cuándo fue la última vez que visitó usted a un dentista?	☐ 0-6 meses ☐ 6meses - <1 año ☐ 1-5 años ☐ más de 5 años ☐ Nunca
14	¿Cuándo fue la última vez que visitó usted a un medico?	☐ 0-6 meses ☐ 6meses - <1 año ☐ 1-5 años ☐ más de 5 años ☐ Nunca
15	¿Que tan lejos está el dentista que usted visitó?	En millas _____ en horas ______
16	¿Que tan lejos está el doctor que usted visitó?	En millas _____ en horas ______
17	¿Cuándo fue la última vez que llevó a su hijo(a) a un	☐ 0- <6 meses ☐ 6meses - <1 año ☐ 1-5 años ☐ más de 5 años ☐ Nunca

	dentista?	
18	¿Cuándo fue la última vez que llevó a su hijo a un doctor?	☐ 0- <6 meses ☐ 6meses - <1 año ☐ 1-5 años ☐ más de 5 años ☐ Nunca
19	¿Que medio de transporte ultilizó para ir al dentista la última vez?	☐ mi carro/camioneta ☐ vehículo de un amigo(a)/familiar ☐ transporte público ☐ otro____________
20	¿Qué tan lejos está el dentista que visitó con su hijo la última vez?	En millas _____ en horas ______
21	¿Qué tan lejos está el doctor que visitó con su hijo la última vez?	En millas _____ en horas ______
22	¿Qué tanto tiempo tiene que esperar para hacer una cita con un dentista?	☐ ninguno ☐ algunas horas ☐ algunos dias ☐ más que algunos dias
23	¿Qué tanto tiempo tiene que esperar para hacer una cita con un doctor?	☐ ninguno ☐ algunas horas ☐ algunos dias ☐ más que algunos dias
24	¿Qué tanto tiempo tiene que esperar en el consultorio del dentista?	☐ 0-30 min ☐ 31 min-1 hr ☐ > 1 hr
25	¿Qué tanto tiempo tiene que esperar en el consultorio del doctor?	☐ 0-30 min ☐ 31 min-1 hr ☐ > 1 hr
26	¿Qué tanto tiempo necesita salirse del trabajo para llevar a su hijo(a) al dentista? (¿si no lo ha hecho, cuánto tiempo piensa usted que necesitaría?)	☐ 0- 1 hr ☐ 1 hr - <4 hrs ☐ medio día - todo el día (4-8 hrs) ☐ > 8 hrs
27	¿Qué tanto tiempo necesita salirse del trabajo para llevar a su hijo(a) al doctor? (¿si no lo ha hecho, cuanto tiempo piensa usted que necesitaría?)	☐ 0- 1 hr ☐ 1 hr - <4 hrs ☐ medio día - todo el día (4-8 hrs) ☐ > 8 hrs
28	¿Cuántos de sus dientes le han sacado?	☐ ninguno ☐ 1-5 ☐ más de 5
29	¿Cuanto pagó en su ultima visita al dentista?	☐ $0 ☐ $1-$20 ☐ $21- $50 ☐ $51- $100 ☐ no sé
30	¿Durante el último año, ha cruzado la frontera para recibir cuidado dental?	
	• *¿para usted?*	☐ Si ☐ No
	• *¿para su hijo(a)?*	☐ Si ☐ No
31	¿Durante el último año, ha cruzado la frontera para recibir cuidado médico?	
	• *¿para usted?*	☐ Si ☐ No
	• *¿para su hijo(a)?*	☐ Si ☐ No
32	¿Ha cruzado usted la frontera en los últimos 12 meses para adquirir medicina?	
	• *¿para usted?*	☐ Si ☐ No
	• *¿para su hijo(a)?*	☐ Si ☐ No
33	¿Conoce usted del proyecto "telehealth" en la escuela	☐ Si ☐ No

	de su hijo donde el cuidado dental es brindado utilizando computadoras y telecomunicación?	
34	¿Cómo describiría usted su grado de satisfacción con el servicio brindado por "telehealth" en la escuela de sus hijos?	☐ muy satisfecho ☐ satisfecho ☐ Insatisfecho ☐ altamente insatisfecho
35	¿Piensa usted que brindar servicios dentales a través de la escuela le ayuda a ahorrar dinero en las necesidades dentales que requiere su hijo?	☐ Si ☐ No ☐ no sé
36	¿Estaría usted satisfecho si su hijo recibiera cuidado dental, educación sobre la salud y asesoramiento relacionado con la nutrición por parte de un higienista dental licenciado en Lyford CISD?	☐ Si ☐ No ☐ no sé
37	¿Estaría usted satisfecho si sus hijo fueran explorados regularmente por un higienista dental licenciado en Lyford CISD a través del "telehealth" y supervisado por un dentista local afiliado para prevenir enfermedades orales (caries, enfermedades de las encías, ect.)?	☐ Si ☐ No ☐ no sé
38	¿Estaría usted satisfecho si sus hijo fueran explorados regularmente para detectar enfermedades crónicas (asma, diabetes, obesidad) en Lyford CIDS por una enfermera licenciada?	☐ Si ☐ No ☐ no sé
39	¿Estaría usted satisfecho si sus hijo fueran explorados regularmente para detectar enfermedades crónicas (asma, diabetes, obesidad) en Lyford CIDS por una enfermera licenciada?	☐ Si ☐ No ☐ no sé
40	Cuanto tiempo lleva residiendo en Willacy County?	☐ 0- <6meses ☐ 6meses- <1 año ☐ 1-5 años ☐ mas de 5 años
41	¿En dónde nació usted? (opcional)	☐ USA ☐ Mexico ☐ Latinoamérica ☐ Otro ____________________
42	¿Dónde nacieron sus hijos? (opcional)	☐ USA ☐ Mexico ☐ Latinoamérica ☐ Otro ____________________
43	¿A que raza pertenece? (opcional)	☐ Hispánica ☐ Anglo ☐ Negro ☐ Otra ____________________
44	¿Qué idioma(s) habla?	☐ Sólo Español ☐ Español e Ingles ☐ Sólo Ingles ☐ Otro Idioma _____________
45	¿Cual es el estado de su empleo?	☐ Tiempo completo ☐ medio-tiempo ☐ Irregular ☐ desempleado
46	¿Cuanto gana a la semana?	☐ Menos de $6 ☐ $6-$10 ☐ $11-$20 ☐ $21-$50 ☐ More de $50
47	¿Cuál es el total de sus ingresos al año en su hogar?	☐ Menos de $10,000 ☐ $10,000 to $25,000

	(incluyendo a todos los que ganan un salario en su hogar)	☐ $25,001 – $50,0000 ☐ Mas de $50,000
48	¿Cual es su nivel de educación?	☐ Ninguno ☐ 1-8o año ☐ preparatoria ☐ Carrera Tecnica ☐ Licenciatura ☐ Post-Grado

Favor de regresar estas formulario rellenado a la oficina de la escuela de su hijo o a Anjum Khurshid, The University of Texas at Austin , PO Box Y, Austin, TX 78713 o envíelas por fax al 512-328-6269.
Agradecemos mucho su participación

Appendix 5.A: Household income variable

The original household income variable in the survey had four categories: <$10,000; >$10,000-$25,000; >25,000-$50,000; >$50,000. The coefficients for the third and fourth categories showed remarkable similarity and statistical significance while the lower income categories were closer to each other and statistically not significant. We used Wald test to check if the coefficients are the same and found that not to be correct. Based on Wald test and results from regression shown below, we grouped household income categories 1 and 2 to make a low income category <$25,000 and a high income category of >$25,000 by combining the other two categories. Hence, the transformed variable is *hincome2*, where 0 is low income and 1 is high income.

```
. logit caries2 seals hincome

Iteration 0:   log likelihood = -152.68082
Iteration 1:   log likelihood =  -144.0174
Iteration 2:   log likelihood =  -143.8741
Iteration 3:   log likelihood = -143.87372

Logit estimates                                   Number of obs   =        223
                                                  LR chi2(2)      =      17.61
                                                  Prob > chi2     =     0.0001
Log likelihood = -143.87372                       Pseudo R2       =     0.0577

------------------------------------------------------------------------------
     caries2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       seals |   -1.35799   .4265044    -3.18   0.001    -2.193923   -.5220565
     hincome |  -.3613953   .1521228    -2.38   0.018    -.6595504   -.0632401
       _cons |   .7148229    .355551     2.01   0.044     .0179557     1.41169
------------------------------------------------------------------------------


. xi: logit caries2 seals i.hincome
i.hincome         _Ihincome_1-4       (naturally coded; _Ihincome_1 omitted)
```

```
Iteration 0:   log likelihood = -152.68082
Iteration 1:   log likelihood = -143.83648
Iteration 2:   log likelihood =  -143.6748
Iteration 3:   log likelihood = -143.67435

Logit estimates                                   Number of obs   =        223
                                                  LR chi2(4)      =      18.01
                                                  Prob > chi2     =     0.0012
Log likelihood = -143.67435                       Pseudo R2       =     0.0590

------------------------------------------------------------------------------
     caries2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       seals |  -1.364623   .4269203    -3.20   0.001    -2.201372   -.5278747
 _Ihincome_2 |  -.1798155   .3431364    -0.52   0.600    -.8523505    .4927195
 _Ihincome_3 |  -.6401765   .3781197    -1.69   0.090    -1.381278    .1009245
 _Ihincome_4 |  -1.173646   .5831962    -2.01   0.044     -2.31669   -.0306025
       _cons |   .2733181   .2597382     1.05   0.293    -.2357595    .7823956
------------------------------------------------------------------------------

. test _Ihincome_2=_Ihincome_3=_Ihincome_4

 ( 1)  _Ihincome_2 - _Ihincome_3 = 0
 ( 2)  _Ihincome_2 - _Ihincome_4 = 0

           chi2(  2) =    3.71
         Prob > chi2 =    0.1562


. test _Ihincome_3=_Ihincome_4

 ( 1)  _Ihincome_3 - _Ihincome_4 = 0

           chi2(  1) =    0.80
         Prob > chi2 =    0.3699

. test _Ihincome_2=_Ihincome_3

 ( 1)  _Ihincome_2 - _Ihincome_3 = 0

           chi2(  1) =    1.60
         Prob > chi2 =    0.2059
```

APPENDIX 5. B: Multivariate probit model results for dental caries

Multivariate probit models using Stata 9.0 and user-developed module, mvprobit. The routine has default number of draws as 5, but we try more draws to check the robustness of the results of likelihood ratio test for no endogeneity. We reduce some not statistically significant variables from the model to increase the number of observations used in the multivariate probit model. We find convergence more easily with higher number of observations and find consistent results of the estimators. The LR test is rejected using different seeds and draws as shown below. A combination of maximizing algorithms, such as BFGS and NR are used.

1) Multivariate probit model with Draws=350, seed=88, technique bfgs=10, nr=10

```
Multivariate probit (MSL, # draws = 350)          Number of obs   =        190
                                                  Wald chi2(20)   =      62.47
Log likelihood =  -296.3861                       Prob > chi2     =     0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
caries2      |
       seals |  -.9840922   1.005902    -0.98   0.328    -2.955625    .9874401
         sex |  -.2404953   .2085444    -1.15   0.249    -.6492349    .1682443
       c_age |   .0481676   .0833239     0.58   0.563    -.1151443    .2114795
    hincome2 |   -.618279   .2751238    -2.25   0.025    -1.157512   -.0790464
 _Ip_educ3_1 |   .2587871   .3288531     0.79   0.431    -.3857531    .9033273
 _Ip_educ3_2 |   .3804015   .3903144     0.97   0.330    -.3846005    1.145404
      p_hins |  -.1389064   .2785144    -0.50   0.618    -.6847846    .4069718
    dentfreq |  -.5089293   1.054387    -0.48   0.629    -2.575489     1.55763
       _cons |  -.0531864   1.021169    -0.05   0.958    -2.054641    1.948268
-------------+----------------------------------------------------------------
seals        |
         sex |   .0372902   .2415916     0.15   0.877    -.4362207    .5108011
       c_age |   .2712607   .0539676     5.03   0.000     .1654862    .3770353
    hincome2 |  -.2919799   .3355197    -0.87   0.384    -.9495865    .3656267
 _Ip_educ3_1 |  -.5034714   .2901214    -1.74   0.083    -1.072099     .065156
 _Ip_educ3_2 |  -.6015908   .4020869    -1.50   0.135    -1.389667     .186485
      p_hins |   .6164856   .2967246     2.08   0.038      .034916    1.198055
       _cons |  -4.119168   .7307716    -5.64   0.000    -5.551454   -2.686882
-------------+----------------------------------------------------------------
dentfreq     |
         sex |  -.3533019   .2050941    -1.72   0.085    -.7552789    .0486752
```

```
       c_age |   .0598927   .0469954     1.27   0.203    -.0322167    .1520021
    hincome2 |  -.5179209   .2476115    -2.09   0.036    -1.003231   -.0326112
  _Ip_educ3_1 |   -.468071   .2700733    -1.73   0.083     -.997405    .0612629
  _Ip_educ3_2 |  -.2556389   .3532249    -0.72   0.469     -.947947    .4366692
      p_hins |   .0724693   .2496681     0.29   0.772    -.4168711    .5618097
       _cons |   .5260606   .6024568     0.87   0.383    -.6547331    1.706854
-------------+----------------------------------------------------------------
    /atrho21 |    .117359   .6030227     0.19   0.846    -1.064544    1.299262
-------------+----------------------------------------------------------------
    /atrho31 |   .3584677    .698244     0.51   0.608    -1.010065    1.727001
-------------+----------------------------------------------------------------
    /atrho32 |  -.0549222   .1707004    -0.32   0.748    -.3894888    .2796444
-------------+----------------------------------------------------------------
       rho21 |   .1168232   .5947928     0.20   0.844    -.7873967     .861533
-------------+----------------------------------------------------------------
       rho31 |   .3438636   .6156821     0.56   0.576    -.7657891    .9387005
-------------+----------------------------------------------------------------
       rho32 |  -.0548671   .1701865    -0.32   0.747    -.3709195    .2725759
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  .359668   Prob > chi2 = 0.9484
```

2) Multivariate probit model with Draws=350, seed=666, technique bfgs=10, nr=10

```
Multivariate probit (MSL, # draws = 350)          Number of obs   =        190
                                                  Wald chi2(20)   =      58.56
Log likelihood =  -296.4696                       Prob > chi2     =     0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
caries2      |
       seals |  -.6516622   1.515461    -0.43   0.667    -3.621912    2.318587
         sex |  -.2483246    .226112    -1.10   0.272     -.691496    .1948468
       c_age |     .02765   .0981975     0.28   0.778    -.1648135    .2201135
    hincome2 |  -.6126496    .287891    -2.13   0.033    -1.176906   -.0483936
  _Ip_educ3_1 |   .2848881    .340632     0.84   0.403    -.3827384    .9525145
  _Ip_educ3_2 |   .4277264   .3930027     1.09   0.276    -.3425447    1.197998
      p_hins |  -.1828854   .2937988    -0.62   0.534    -.7587205    .3929497
    dentfreq |  -.5969572   1.583664    -0.38   0.706    -3.700881    2.506966
       _cons |   .1895203   1.708409     0.11   0.912    -3.158899     3.53794
-------------+----------------------------------------------------------------
seals        |
         sex |   .0299419   .2439488     0.12   0.902    -.4481889    .5080726
       c_age |   .2711941   .0541813     5.01   0.000     .1650007    .3773875
    hincome2 |  -.3183542   .3415275    -0.93   0.351    -.9877358    .3510274
  _Ip_educ3_1 |  -.4872055   .2942098    -1.66   0.098    -1.063846     .089435
  _Ip_educ3_2 |  -.6005453   .4039527    -1.49   0.137    -1.392278    .1911876
      p_hins |    .642939   .3060728     2.10   0.036     .0430473    1.242831
       _cons |  -4.125514    .731837    -5.64   0.000    -5.559888    -2.69114
-------------+----------------------------------------------------------------
dentfreq     |
         sex |  -.3520156   .2053022    -1.71   0.086    -.7544005    .0503693
       c_age |   .0590286   .0468605     1.26   0.208    -.0328162    .1508734
    hincome2 |  -.5152305   .2480624    -2.08   0.038    -1.001424   -.0290372
  _Ip_educ3_1 |  -.4678706    .271113    -1.73   0.084    -.9992423    .0635012
```

```
 _Ip_educ3_2 |  -.2579371   .3543779    -0.73   0.467    -.9525049    .4366308
      p_hins |   .0738919    .251465     0.29   0.769    -.4189705    .5667543
       _cons |    .535689   .6017792     0.89   0.373    -.6437765    1.715155
-------------+----------------------------------------------------------------
    /atrho21 |  -.0712509   .8198648    -0.09   0.931    -1.678157    1.535655
-------------+----------------------------------------------------------------
    /atrho31 |   .4217826   1.117529     0.38   0.706    -1.768534    2.612099
-------------+----------------------------------------------------------------
    /atrho32 |  -.0273717    .175291    -0.16   0.876    -.3709357    .3161924
-------------+----------------------------------------------------------------
       rho21 |  -.0711306   .8157167    -0.09   0.931    -.9326219    .9113873
-------------+----------------------------------------------------------------
       rho31 |   .3984311   .9401244     0.42   0.672    -.9434486    .9892883
-------------+----------------------------------------------------------------
       rho32 |  -.0273648   .1751597    -0.16   0.876    -.3548099      .30606
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  .192674   Prob > chi2 = 0.9788
```

3) Multivariate probit model with Draws=350, seed=212, technique bfgs=10, nr=10

```
Multivariate probit (MSL, # draws = 350)          Number of obs   =        190
                                                  Wald chi2(20)   =      67.49
Log likelihood = -296.12161                       Prob > chi2     =     0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
caries2      |
       seals |  -.7514317   1.245324    -0.60   0.546    -3.192222    1.689358
         sex |  -.2836092   .1914466    -1.48   0.138    -.6588376    .0916192
       c_age |   .0445687   .0933256     0.48   0.633    -.1383462    .2274836
    hincome2 |  -.6568653   .2408487    -2.73   0.006     -1.12892   -.1848105
 _Ip_educ3_1 |   .1750867   .3484434     0.50   0.615    -.5078498    .8580232
 _Ip_educ3_2 |   .3417131   .4102812     0.83   0.405    -.4624232    1.145849
      p_hins |  -.1390347    .290217    -0.48   0.632    -.7078495    .4297801
    dentfreq |   -1.07589   .8985579    -1.20   0.231    -2.837031    .6852516
       _cons |   .4665746   1.038192     0.45   0.653    -1.568244    2.501394
-------------+----------------------------------------------------------------
seals        |
         sex |    .033499   .2420634     0.14   0.890    -.4409365    .5079346
       c_age |   .2714976   .0540753     5.02   0.000      .165512    .3774832
    hincome2 |  -.3058173   .3380311    -0.90   0.366    -.9683461    .3567114
 _Ip_educ3_1 |  -.4950372    .292752    -1.69   0.091    -1.068821    .0787462
 _Ip_educ3_2 |  -.6013688   .4032645    -1.49   0.136    -1.391753    .1890151
      p_hins |   .6306518   .3041277     2.07   0.038     .0345724    1.226731
       _cons |  -4.126049   .7316815    -5.64   0.000    -5.560119    -2.69198
-------------+----------------------------------------------------------------
dentfreq     |
         sex |   -.360186   .2043769    -1.76   0.078    -.7607573    .0403854
       c_age |   .0596595   .0465875     1.28   0.200    -.0316503    .1509692
    hincome2 |  -.5176742   .2484971    -2.08   0.037    -1.004719   -.0306289
 _Ip_educ3_1 |  -.4499686   .2710112    -1.66   0.097    -.9811408    .0812036
 _Ip_educ3_2 |  -.2320853   .3590474    -0.65   0.518    -.9358052    .4716346
      p_hins |   .0744001   .2525585     0.29   0.768    -.4206055    .5694058
```

```
       _cons |   .5165177   .6001215     0.86   0.389    -.6596989    1.692734
-------------+----------------------------------------------------------------
    /atrho21 |    .013724   .7293082     0.02   0.985    -1.415694    1.443142
-------------+----------------------------------------------------------------
    /atrho31 |   .8455817   1.047718     0.81   0.420    -1.207908    2.899072
-------------+----------------------------------------------------------------
    /atrho32 |  -.0410266   .1684926    -0.24   0.808     -.371266    .2892127
-------------+----------------------------------------------------------------
       rho21 |   .0137231   .7291708     0.02   0.985    -.8886971    .8943284
-------------+----------------------------------------------------------------
       rho31 |   .6887542   .5506992     1.25   0.211     -.836051     .993952
-------------+----------------------------------------------------------------
       rho32 |  -.0410036   .1682093    -0.24   0.807    -.3550985      .28141
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  .888665   Prob > chi2 = 0.8282
```

4) Multivariate probit model: Draws = 100; Seed =88; Techniques bfgs 30 and nr 25

```
Multivariate probit (MSL, # draws = 100)          Number of obs   =        145
                                                  Wald chi2(35)   =      62.74
Log likelihood =  -206.7437                       Prob > chi2     =     0.0027

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
caries2      |
       seals |  -.3306404   .8138368    -0.41   0.685    -1.925731     1.26445
         sex |   .2746516   .3377703     0.81   0.416    -.3873659    .9366692
       c_age |   .0182318   .0773352     0.24   0.814    -.1333424    .1698059
    hincome2 |   -.364103     .61904    -0.59   0.556    -1.577399    .8491931
 _Ip_educ3_1 |  -.3065526   .4944997    -0.62   0.535    -1.275754     .662649
 _Ip_educ3_2 |   .1925478   .4880354     0.39   0.693     -.763984     1.14908
      p_hins |  -.5294286   .3369089    -1.57   0.116    -1.189758    .1309008
      stayw2 |   -.596119   1.160251    -0.51   0.607    -2.870169    1.677931
 p_bcountry2 |  -.8809978   .3598827    -2.45   0.014    -1.586355   -.1756407
       lang2 |  -.3230517   .4529833    -0.71   0.476    -1.210883    .5647793
    dentfreq |  -.5806804   2.969861    -0.20   0.845    -6.401501     5.24014
       _cons |    1.43551   1.752799     0.82   0.413    -1.999914    4.870934
-------------+----------------------------------------------------------------
seals        |
         sex |  -.0235734   .2919332    -0.08   0.936     -.595752    .5486052
       c_age |   .2665512   .0637539     4.18   0.000     .1415957    .3915066
    hincome2 |  -.7000672   .4191336    -1.67   0.095    -1.521554    .1214196
 _Ip_educ3_1 |  -.4217783   .3997243    -1.06   0.291    -1.205224    .3616669
 _Ip_educ3_2 |   -.194484     .56399    -0.34   0.730    -1.299884    .9109162
      p_hins |   .9492085   .3711466     2.56   0.011     .2217744    1.676643
      stayw2 |   .6566113   .5741417     1.14   0.253    -.4686857    1.781908
 p_bcountry2 |    .467605   .3974187     1.18   0.239    -.3113213    1.246531
       lang2 |   .5274327   .5280254     1.00   0.318    -.5074781    1.562344
 p_crossdrug |  -.2665422   .3344429    -0.80   0.425    -.9220382    .3889537
   knowmed2 |   .1137221    .367512     0.31   0.757    -.6065882    .8340324
    dtransp2 |   -4.90173   130.4639    -0.04   0.970    -260.6064    250.8029
       _cons |  -5.168697    1.18006    -4.38   0.000    -7.481573   -2.855821
-------------+----------------------------------------------------------------
dentfreq     |
         sex |  -.2428639   .2910349    -0.83   0.404    -.8132819     .327554
```

```
       c_age |   .0418081   .0602269     0.69   0.488    -.0762346    .1598507
    hincome2 |  -.5593149   .3390459    -1.65   0.099    -1.223833    .1052028
 _Ip_educ3_1 |   -.727782   .4475828    -1.63   0.104    -1.605028    .1494641
 _Ip_educ3_2 |  -.4298992   .5698831    -0.75   0.451     -1.54685    .6870511
      p_hins |  -.1521808   .3665327    -0.42   0.678    -.8705717      .56621
      stayw2 |   .7856721   .4251346     1.85   0.065    -.0475764    1.618921
 p_bcountry2 |  -.3295969   .4838067    -0.68   0.496    -1.277841    .6186468
       lang2 |   .0547841   .6099924     0.09   0.928    -1.140779    1.250347
 p_crossdrug |  -.2425907   .4054785    -0.60   0.550    -1.037314    .5521326
    knowmed2 |   .0125422   .4447692     0.03   0.978    -.8591894    .8842737
    dtransp2 |   4.035891    155.915     0.03   0.979    -301.5518    309.6236
       _cons |   .5257892   .9811901     0.54   0.592    -1.397308    2.448887
-------------+----------------------------------------------------------------
    /atrho21 |  -.2807677   .4786557    -0.59   0.557    -1.218916    .6573803
-------------+----------------------------------------------------------------
    /atrho31 |   .4064303   2.014472     0.20   0.840    -3.541863    4.354723
-------------+----------------------------------------------------------------
    /atrho32 |   -.228666   .2513466    -0.91   0.363    -.7212963    .2639643
-------------+----------------------------------------------------------------
       rho21 |  -.2736155    .442821    -0.62   0.537     -.839334    .5766174
-------------+----------------------------------------------------------------
       rho31 |   .3854375   1.715198     0.22   0.822    -.9983241      .99967
-------------+----------------------------------------------------------------
       rho32 |  -.2247621   .2386491    -0.94   0.346    -.6177116    .2579997
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
              chi2(3) =  1.50734   Prob > chi2 = 0.6806
```

5) Bivariate probit model as a preliminary estimation before multivariate probit: failure to reject the null **hypothesis** shows that cannot reject the hypothesis that dental caries and dental sealants are not endogenous.

```
Bivariate probit regression                       Number of obs   =        175
                                                  Wald chi2(21)   =      60.39
Log pseudolikelihood = -178.84237                 Prob > chi2     =     0.0000

------------------------------------------------------------------------------
             |               Robust
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
caries2      |
       seals |  -1.037896   1.326365    -0.78   0.434    -3.637524    1.561732
         sex |   .2740471    .208117     1.32   0.188    -.1338547    .6819489
       c_age |   .0303796   .0910145     0.33   0.739    -.1480056    .2087649
    hincome2 |  -.3608111    .245916    -1.47   0.142    -.8427977    .1211754
 _Ip_educ3_1 |  -.2640736   .3290335    -0.80   0.422    -.9089673    .3808202
 _Ip_educ3_2 |   .2045453   .3948282     0.52   0.604    -.5693037    .9783943
      p_hins |  -.4508281   .3251637    -1.39   0.166    -1.088137    .1864811
      stayw2 |   -.514382   .3250339    -1.58   0.114    -1.151437    .1226728
 p_bcountry2 |  -.8655484   .3621187    -2.39   0.017    -1.575288   -.1558087
       lang2 |  -.4295004   .4610891    -0.93   0.352    -1.333218    .4742175
       _cons |    .944795    1.06605     0.89   0.375    -1.144624    3.034214
```

```
-------------+----------------------------------------------------------------
seals        |
         sex |   .0209578   .2346178     0.09   0.929    -.4388847    .4808002
       c_age |   .2238748   .0482747     4.64   0.000     .1292581    .3184915
    hincome2 |  -.0783989   .3055492    -0.26   0.798    -.6772643    .5204666
 _Ip_educ3_1 |  -.3841826   .3287568    -1.17   0.243    -1.028534    .2601688
 _Ip_educ3_2 |  -.1875955   .4376966    -0.43   0.668    -1.045465     .670274
      p_hins |   .4991357   .2919892     1.71   0.087    -.0731526    1.071424
      stayw2 |   .2216279   .3944252     0.56   0.574    -.5514312    .9946871
 p_bcountry2 |   .3928159   .2972874     1.32   0.186    -.1898567    .9754884
       lang2 |   .2990406    .456525     0.66   0.512    -.5957319    1.193813
 p_crossdrug |  -.3316412   .2636386    -1.26   0.208    -.8483634     .185081
    knowmed2 |   .0822185   .2919101     0.28   0.778    -.4899147    .6543517
       _cons |   -4.13011   .8663471    -4.77   0.000    -5.828119   -2.432101
-------------+----------------------------------------------------------------
     /athrho |    .105776   .7933675     0.13   0.894    -1.449196    1.660748
-------------+----------------------------------------------------------------
         rho |   .1053832   .7845567                      -.8955337    .9303178
------------------------------------------------------------------------------
Wald test of rho=0:                  chi2(1) =  .017776    Prob > chi2 = 0.8939
```

APPENDIX 6.A : Description of variables and their values

Description of variables in the data with their values.

Variables	**Values & labels**
Any caries	0 = no , 1 = yes
Any sealants	0 = no , 1 = yes
Age	Continuous
Sex	0 = female, 1 = male
Race	0 = Hispanic, 1 = Non Hispanic
Parent's education	0 = < High School, 1 = High School, 2 = > High School
Annual household income >$25k	0 = <$25K, 1 = > $25k
Parent's dental insurance status	0 = no , 1 = yes
Parent's health insurance status	0 = no , 1 = yes
Child's health insurance status	0 = no , 1 = yes
Child's dental insurance status	0 = no , 1 = yes
Crossing border for parent's dental	0 = no , 1 = yes
Crossing border for child's dental	0 = no , 1 = yes
Stay in Willacy County >5 years	0 = no , 1 = yes
Child's country of birth	0 = USA , 1 = outside USA
Parent's country of birth	0 = USA , 1 = outside USA
Language spoken at home	0 = Spanish only , 1 = English (with or without any Spanish)
Knowledge of Medicaid eligibility of child	0 = no , 1 = yes
Knowledge of teledentistry project at school	0 = no , 1 = yes
Dental frequency as last visit	0 = ≥ one year, 1 = < one year
Parent's work type	0 = employed full- or half-time, 1 = not employed

APPENDIX 6.B: Multivariate probit model results for dental utilization

Results from multivariate probit models using Stata 9.0 and a user developed routine, mvprobit, are shown below. Convergence of the model was not always possible with higher number of draws. At some lower draw numbers the LR test rejected the null hypothesis at the 10% significance level. However, with higher number of draws the LR results were consistent when the model converged. Different seeds and draws were used to find consistency of results. Few examples with higher number of draws are shown below. These results reject the null hypothesis of no endogeneity, thus allowing us to use univariate probit model for our estimation without serious concerns for biased and inconsistent estimators.

1) Multivariate model with 350 draws and seed of 88, technique BFGS 10 and NR 10

```
Multivariate probit (MSL, # draws = 350)          Number of obs   =        150
                                                  Wald chi2(38)   =      79.65
Log likelihood = -215.91425                       Prob > chi2     =     0.0001

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dentfreq     |
     caries2 |  -.7922813   .8724557    -0.91   0.364    -2.502263    .9177004
       seals |  -.5784545   1.069964    -0.54   0.589    -2.675546    1.518637
         sex |  -.4273357   .2806278    -1.52   0.128    -.9773561    .1226847
       c_age |   .1304255   .0845287     1.54   0.123    -.0352478    .2960988
    hincome2 |  -.4202964   .3210044    -1.31   0.190    -1.049454    .2088607
 _Ip_educ3_1 |  -.4914165   .5267901    -0.93   0.351    -1.523906    .5410731
 _Ip_educ3_2 |  -.4303854   .6236086    -0.69   0.490    -1.652636    .7918649
      c_dins |   .9604793   .4029442     2.38   0.017     .1707232    1.750235
      p_hins |  -.3611821   .3871195    -0.93   0.351    -1.119922    .3975582
      stayw2 |   .6026221   .5699686     1.06   0.290    -.5144958     1.71974
 p_bcountry2 |  -.1502096   .5271459    -0.28   0.776    -1.183397    .8829774
       lang2 |   .0475568   .6335673     0.08   0.940    -1.194212    1.289326
  c_crossden |   .6465162   .5181761     1.25   0.212    -.3690903    1.662123
   worktype2b |  -.4444316   .2918746    -1.52   0.128    -1.016495    .1276321
       _cons |  -.1813405   1.485161    -0.12   0.903    -3.092202    2.729521
-------------+----------------------------------------------------------------
```

```
caries2      |
         sex |   .0736088   .2277509     0.32   0.747    -.3727747    .5199923
       c_age |   .0177074   .0472311     0.37   0.708    -.0748639    .1102786
    hincome2 |  -.4592663   .2972192    -1.55   0.122    -1.041805    .1232726
 _Ip_educ3_1 |   .4656561   .3590021     1.30   0.195    -.2379751    1.169287
 _Ip_educ3_2 |   .6672672   .4784003     1.39   0.163    -.2703801    1.604915
      c_dins |  -.1760755   .2592066    -0.68   0.497    -.6841112    .3319602
      p_hins |  -.4606633    .301939    -1.53   0.127    -1.052453    .1311261
      stayw2 |  -.6978624   .3540571    -1.97   0.049    -1.391802   -.0039232
 p_bcountry2 |  -1.148123   .5026543    -2.28   0.022    -2.133307   -.1629386
       lang2 |  -.9857437   .5617005    -1.75   0.079    -2.086656    .1151689
  c_crossden |   -.261719   .4474668    -0.58   0.559    -1.138738    .6152999
  worktype2b |  -.2068304   .2489016    -0.83   0.406    -.6946685    .2810077
       _cons |   1.404754   .8556285     1.64   0.101    -.2722471    3.081755
-------------+----------------------------------------------------------------
seals        |
         sex |  -.2307456   .2791475    -0.83   0.408    -.7778647    .3163734
       c_age |   .2567127   .0600063     4.28   0.000     .1391025    .3743229
    hincome2 |  -.6778606   .4177026    -1.62   0.105    -1.496543    .1408214
 _Ip_educ3_1 |   -.480077   .4007382    -1.20   0.231     -1.26551    .3053555
 _Ip_educ3_2 |   -.365344   .5848556    -0.62   0.532     -1.51164    .7809519
      c_dins |  -.3210409   .3336273    -0.96   0.336    -.9749383    .3328565
      p_hins |   .9088438   .3769939     2.41   0.016     .1699493    1.647738
      stayw2 |   .5878707    .542192     1.08   0.278    -.4748061    1.650547
 p_bcountry2 |   .5942485   .4368828     1.36   0.174    -.2620262    1.450523
       lang2 |   .7263844   .5666242     1.28   0.200    -.3841786    1.836947
  c_crossden |  -.1957744   .5581578    -0.35   0.726    -1.289744    .8981948
  worktype2b |  -.0237969   .3193514    -0.07   0.941    -.6497141    .6021203
       _cons |  -4.965847   1.076107    -4.61   0.000    -7.074978   -2.856717
-------------+----------------------------------------------------------------
    /atrho21 |   .7290119   .8258872     0.88   0.377    -.8896972    2.347721
-------------+----------------------------------------------------------------
    /atrho31 |   .1359216   .6449522     0.21   0.833    -1.128161    1.400005
-------------+----------------------------------------------------------------
    /atrho32 |  -.3202019   .1789652    -1.79   0.074    -.6709672    .0305635
-------------+----------------------------------------------------------------
       rho21 |   .6224605   .5058914     1.23   0.219    -.7112442    .9818918
-------------+----------------------------------------------------------------
       rho31 |   .1350907   .6331821     0.21   0.831    -.8103891    .8853526
-------------+----------------------------------------------------------------
       rho32 |  -.3096894   .1618011    -1.91   0.056    -.5856158     .030554
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =   4.8986   Prob > chi2 = 0.1794
```

2) Multivariate model with 350 draws and seed of 666, technique BFGS 10 and NR 10

```
Multivariate probit (MSL, # draws = 300)          Number of obs   =        150
                                                  Wald chi2(38)   =      69.25
Log likelihood = -216.15094                       Prob > chi2     =     0.0014

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dentfreq     |
     caries2 |   .1451292   2.381621     0.06   0.951    -4.522762     4.81302
       seals |  -.7307174    1.29273    -0.57   0.572    -3.264421    1.802986
         sex |  -.5014944   .2792573    -1.80   0.073    -1.048829    .0458399
```

```
       c_age |   .1433096   .0887093     1.62   0.106    -.0305574    .3171767
    hincome2 |  -.3217176   .4699384    -0.68   0.494     -1.24278    .5993448
 _Ip_educ3_1 |  -.7504409   .6638384    -1.13   0.258     -2.05154    .5506584
 _Ip_educ3_2 |  -.7063466   .8163482    -0.87   0.387     -2.30636    .8936664
      c_dins |   1.136006   .4038582     2.81   0.005     .3444584    1.927554
      p_hins |  -.2571788   .5608542    -0.46   0.647    -1.356433    .8420754
      stayw2 |   .9480192   .7280283     1.30   0.193      -.47889    2.374928
 p_bcountry2 |   .1200391     .87902     0.14   0.891    -1.602808    1.842887
       lang2 |   .2960643    .921952     0.32   0.748    -1.510928    2.103057
  c_crossden |   .7687313   .5472833     1.40   0.160    -.3039243    1.841387
  worktype2b |  -.4194686   .3529172    -1.19   0.235    -1.111174    .2722364
       _cons |  -1.125366   2.559122    -0.44   0.660    -6.141154    3.890421
-------------+----------------------------------------------------------------
caries2      |
         sex |   .0557952   .2253266     0.25   0.804    -.3858369    .4974273
       c_age |   .0157597   .0479719     0.33   0.743    -.0782634    .1097829
    hincome2 |  -.4244656   .2942318    -1.44   0.149    -1.001149    .1522181
 _Ip_educ3_1 |   .4731633   .3492033     1.35   0.175    -.2112626    1.157589
 _Ip_educ3_2 |    .617334   .4734104     1.30   0.192    -.3105333    1.545201
      c_dins |  -.2132375    .259976    -0.82   0.412     -.722781     .296306
      p_hins |  -.4057385   .3094885    -1.31   0.190    -1.012325    .2008478
      stayw2 |  -.6709609   .3533584    -1.90   0.058    -1.363531    .0216088
 p_bcountry2 |  -1.014901   .5378285    -1.89   0.059    -2.069025    .0392236
       lang2 |  -.8583598   .6351068    -1.35   0.177    -2.103146    .3864266
  c_crossden |  -.2364651   .4578138    -0.52   0.605    -1.133764    .6608335
  worktype2b |  -.2066739   .2508218    -0.82   0.410    -.6982756    .2849278
       _cons |   1.278537    .892583     1.43   0.152    -.4708935    3.027968
-------------+----------------------------------------------------------------
seals        |
         sex |  -.2357172   .2807186    -0.84   0.401    -.7859154    .3144811
       c_age |   .2549021   .0604303     4.22   0.000     .1364608    .3733434
    hincome2 |  -.6766064   .4154725    -1.63   0.103    -1.490917    .1377047
 _Ip_educ3_1 |  -.4594258   .4036856    -1.14   0.255    -1.250635    .3317835
 _Ip_educ3_2 |  -.3596269    .586853    -0.61   0.540    -1.509838    .7905838
      c_dins |  -.3196627   .3331358    -0.96   0.337    -.9725968    .3332714
      p_hins |   .9176653   .3798779     2.42   0.016     .1731182    1.662212
      stayw2 |   .5704387   .5380937     1.06   0.289    -.4842056    1.625083
 p_bcountry2 |   .6089776   .4383369     1.39   0.165    -.2501471    1.468102
       lang2 |    .710301   .5699954     1.25   0.213    -.4068695    1.827471
  c_crossden |  -.2076235   .5598537    -0.37   0.711    -1.304916    .8896695
  worktype2b |  -.0281187   .3189458    -0.09   0.930     -.653241    .5970037
       _cons |  -4.923199   1.079458    -4.56   0.000    -7.038898     -2.8075
-------------+----------------------------------------------------------------
    /atrho21 |   .0569256   1.471688     0.04   0.969    -2.827531    2.941382
-------------+----------------------------------------------------------------
    /atrho31 |   .3357387   .9384009     0.36   0.721    -1.503493    2.174971
-------------+----------------------------------------------------------------
    /atrho32 |  -.3491001   .1960848    -1.78   0.075    -.7334193    .0352191
-------------+----------------------------------------------------------------
       rho21 |   .0568642    1.46693     0.04   0.969    -.9930249    .9944414
-------------+----------------------------------------------------------------
       rho31 |   .3236678   .8400933     0.39   0.700    -.9057775    .9745138
-------------+----------------------------------------------------------------
       rho32 |  -.3355772   .1740033    -1.93   0.054    -.6251528    .0352046
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  4.42522   Prob > chi2 = 0.2191
```

3) Multivariate model with 300 draws and seed of 88, technique BFGS 10 and NR 10

```
Multivariate probit (MSL, # draws = 300)          Number of obs   =        150
                                                  Wald chi2(38)   =      76.69
Log likelihood = -216.00894                       Prob > chi2     =     0.0002

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dentfreq     |
     caries2 |  -.6861607   1.169004    -0.59   0.557    -2.977367    1.605045
       seals |  -.6671609   1.257139    -0.53   0.596    -3.131108    1.796787
         sex |  -.4439111   .2944874    -1.51   0.132    -1.021096    .1332736
       c_age |   .1365337   .0913223     1.50   0.135    -.0424547    .3155221
    hincome2 |  -.4182985   .3305826    -1.27   0.206    -1.066229    .2296315
  _Ip_educ3_1 |  -.5326596    .586475    -0.91   0.364    -1.682129    .6168102
  _Ip_educ3_2 |  -.4708772   .6814957    -0.69   0.490    -1.806584    .8648298
      c_dins |   .9866096   .4418839     2.23   0.026      .120533    1.852686
      p_hins |  -.3393086   .4210132    -0.81   0.420    -1.164479     .485862
      stayw2 |   .6595174   .6601673     1.00   0.318    -.6343867    1.953421
  p_bcountry2 |  -.1146676   .5809759    -0.20   0.844    -1.253359    1.024024
       lang2 |   .0833386   .6861248     0.12   0.903    -1.261441    1.428119
   c_crossden |   .6613847   .5400287     1.22   0.221     -.397052    1.719822
   worktype2b |   -.447515   .2953096    -1.52   0.130    -1.026311    .1312813
       _cons |  -.3330665   1.761678    -0.19   0.850    -3.785891    3.119758
-------------+----------------------------------------------------------------
caries2      |
         sex |   .0679874   .2273728     0.30   0.765    -.3776551    .5136299
       c_age |   .0180546   .0474116     0.38   0.703    -.0748704    .1109795
    hincome2 |  -.4506268     .29846    -1.51   0.131    -1.035598    .1343441
  _Ip_educ3_1 |   .4668377   .3582217     1.30   0.193     -.235264    1.168939
  _Ip_educ3_2 |   .6634061   .4803012     1.38   0.167    -.2779669    1.604779
      c_dins |  -.1799169   .2616048    -0.69   0.492     -.692653    .3328191
      p_hins |  -.4555643   .3054471    -1.49   0.136     -1.05423     .143101
      stayw2 |  -.6979783   .3554345    -1.96   0.050    -1.394617   -.0013395
  p_bcountry2 |  -1.137689   .5142774    -2.21   0.027    -2.145654   -.1297237
       lang2 |  -.9801648   .5774647    -1.70   0.090    -2.111975    .1516452
   c_crossden |  -.2573211   .4484742    -0.57   0.566    -1.136314    .6216722
   worktype2b |  -.2100775   .2490599    -0.84   0.399    -.6982259    .2780708
       _cons |   1.398654   .8695976     1.61   0.108    -.3057261    3.103034
-------------+----------------------------------------------------------------
seals        |
         sex |  -.2304107   .2801571    -0.82   0.411    -.7795085    .3186871
       c_age |   .2569729   .0603574     4.26   0.000     .1386746    .3752712
    hincome2 |  -.6864462    .421179    -1.63   0.103    -1.511942    .1390494
  _Ip_educ3_1 |  -.4700003   .4032715    -1.17   0.244    -1.260398    .3203974
  _Ip_educ3_2 |  -.3514158   .5930576    -0.59   0.553    -1.513787    .8109558
      c_dins |  -.3174929   .3338576    -0.95   0.342    -.9718418     .336856
      p_hins |    .901281   .3799783     2.37   0.018     .1565372    1.646025
      stayw2 |   .5857467   .5404368     1.08   0.278      -.47349    1.644983
  p_bcountry2 |   .5912553   .4381411     1.35   0.177    -.2674855    1.449996
       lang2 |   .7192036   .5699815     1.26   0.207    -.3979396    1.836347
   c_crossden |  -.1895729   .5605893    -0.34   0.735    -1.288308     .909162
   worktype2b |  -.0267221   .3218816    -0.08   0.934    -.6575985    .6041543
       _cons |   -4.96313   1.077262    -4.61   0.000    -7.074525   -2.851735
-------------+----------------------------------------------------------------
    /atrho21 |   .6246223   .9989203     0.63   0.532    -1.333226     2.58247
```

```
-------------+----------------------------------------------------------------
    /atrho31 |   .1994172   .7930084     0.25   0.801    -1.354851    1.753685
-------------+----------------------------------------------------------------
    /atrho32 |  -.3243574   .1812061    -1.79   0.073    -.6795149    .0308001
-------------+----------------------------------------------------------------
       rho21 |   .5543381   .6919613     0.80   0.423    -.8700355    .9886381
-------------+----------------------------------------------------------------
       rho31 |   .1968152   .7622902     0.26   0.796    -.8751933    .9417935
-------------+----------------------------------------------------------------
       rho32 |  -.3134416   .1634034    -1.92   0.055    -.5912039    .0307904
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  4.70922   Prob > chi2 = 0.1944
```

4) Multivariate probit model with 350 draws and 212 seed with technique BFGS 10 and NR 10

```
Multivariate probit (MSL, # draws = 350)          Number of obs   =        150
                                                  Wald chi2(38)   =      79.44
Log likelihood = -215.42191                       Prob > chi2     =     0.0001

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dentfreq     |
     caries2 |  -.4841116   5.279995    -0.09   0.927    -10.83271    9.864489
       seals |  -1.256342   3.043987    -0.41   0.680    -7.222447    4.709764
         sex |  -.4827978   .5731484    -0.84   0.400    -1.606148    .6405524
       c_age |   .1639944    .171347     0.96   0.339    -.1718396    .4998283
    hincome2 |  -.4178429   .5758388    -0.73   0.468    -1.546466    .7107805
 _Ip_educ3_1 |  -.6352375   1.673845    -0.38   0.704    -3.915914    2.645439
 _Ip_educ3_2 |  -.5799763    1.79367    -0.32   0.746    -4.095505    2.935552
      c_dins |   .9731814   .7693476     1.26   0.206    -.5347122    2.481075
      p_hins |  -.2044738   1.080787    -0.19   0.850    -2.322778     1.91383
      stayw2 |   .7777274   2.096032     0.37   0.711     -3.33042    4.885875
 p_bcountry2 |  -.0013029   1.578458    -0.00   0.999    -3.095024    3.092418
       lang2 |   .2352944   1.710965     0.14   0.891    -3.118135    3.588724
  c_crossden |   .6048858   .5976808     1.01   0.312    -.5665471    1.776319
  worktype2b |  -.4578306    .317781    -1.44   0.150     -1.08067    .1650087
       _cons |   -.843205   6.302148    -0.13   0.894    -13.19519    11.50878
-------------+----------------------------------------------------------------
caries2      |
         sex |   .0589488   .2342911     0.25   0.801    -.4002534     .518151
       c_age |   .0193756    .053301     0.36   0.716    -.0850925    .1238437
    hincome2 |   -.436376    .324029    -1.35   0.178    -1.071461    .1987092
 _Ip_educ3_1 |    .470566   .3603473     1.31   0.192    -.2357017    1.176834
 _Ip_educ3_2 |   .6442064   .5642089     1.14   0.254    -.4616228    1.750036
      c_dins |  -.1881578   .3291213    -0.57   0.568    -.8332238    .4569081
      p_hins |  -.4491411   .4521642    -0.99   0.321    -1.335367    .4370845
      stayw2 |  -.6819843   .3634845    -1.88   0.061    -1.394401    .0304322
 p_bcountry2 |  -1.107637   .8479585    -1.31   0.191    -2.769605    .5543309
       lang2 |  -.9547939   1.021686    -0.93   0.350    -2.957261    1.047674
  c_crossden |  -.2577412   .4690132    -0.55   0.583     -1.17699    .6615079
```

```
  worktype2b | -.2068187   .2509313    -0.82   0.410     -.698635    .2849976
       _cons |  1.350234   1.057162     1.28   0.202    -.7217652    3.422234
-------------+----------------------------------------------------------------
seals        |
         sex | -.2526193   .2782035    -0.91   0.364    -.7978882    .2926495
       c_age |  .2602509   .0617089     4.22   0.000     .1393038    .3811981
    hincome2 |  -.715318   .4344012    -1.65   0.100    -1.566729    .1360927
 _Ip_educ3_1 | -.4192567   .4107578    -1.02   0.307    -1.224327    .3858138
 _Ip_educ3_2 | -.2885692   .5734922    -0.50   0.615    -1.412593    .8354549
      c_dins | -.3054114   .4209814    -0.73   0.468     -1.13052    .5196971
      p_hins |   .854199   .4308147     1.98   0.047     .0098177     1.69858
      stayw2 |  .6198892   .5580216     1.11   0.267    -.4738131    1.713591
 p_bcountry2 |  .5893549   .4683832     1.26   0.208    -.3286593    1.507369
       lang2 |  .7044134   .5862995     1.20   0.230    -.4447124    1.853539
  c_crossden | -.1473156   .6126485    -0.24   0.810    -1.348085    1.053453
  worktype2b | -.0507515    .316737    -0.16   0.873    -.6715447    .5700417
       _cons | -5.018542   1.112306    -4.51   0.000    -7.198621   -2.838462
-------------+----------------------------------------------------------------
    /atrho21 |  .4118986   3.952121     0.10   0.917    -7.334117    8.157914
-------------+----------------------------------------------------------------
    /atrho31 |  .6283215   3.313179     0.19   0.850     -5.86539    7.122032
-------------+----------------------------------------------------------------
    /atrho32 | -.3294013   .2329626    -1.41   0.157    -.7859995    .1271969
-------------+----------------------------------------------------------------
       rho21 |  .3900836   3.350746     0.12   0.907    -.9999991    .9999998
-------------+----------------------------------------------------------------
       rho31 |  .5568953   2.285655     0.24   0.808    -.9999839    .9999987
-------------+----------------------------------------------------------------
       rho32 | -.3179827    .209407    -1.52   0.129    -.6561368    .1265153
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  5.88329   Prob > chi2 = 0.1174
```

5) Bivariate probit model as a preliminary estimation before multivariate probit: failure to reject the null **hypothesis** shows that cannot reject the hypothesis that dental visit frequency and dental caries are not endogenous.

```
Bivariate probit regression                       Number of obs   =        128
                                                  Wald chi2(26)   =      36.22
Log likelihood = -134.03012                       Prob > chi2     =     0.0876

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dentfreq     |
         sex | -.3059142   .2926374    -1.05   0.296     -.879473    .2676446
       c_age |  .0620346   .0675376     0.92   0.358    -.0703367    .1944058
    hincome2 | -.2798984   .3841075    -0.73   0.466    -1.032735    .4729385
 _Ip_educ3_1 | -1.006293   .5594683    -1.80   0.072    -2.102831    .0902446
 _Ip_educ3_2 | -.9429428   .6847545    -1.38   0.168    -2.285037    .3991513
      c_dins |  .9232281   .3384676     2.73   0.006     .2598437    1.586613
```

```
     p_hins |  -.4890869   .3862196    -1.27   0.205    -1.246063    .2678897
     stayw2 |    .880416   .4377826     2.01   0.044     .0223778    1.738454
 p_bcountry2 |  -.0697776   .5612043    -0.12   0.901    -1.169718    1.030163
      lang2 |   .2733226   .6734267     0.41   0.685    -1.046569    1.593215
  c_crossden |    .959364   .5484622     1.75   0.080    -.1156022     2.03433
  c_medelig2 |   .1634208   .3604147     0.45   0.650    -.5429791    .8698207
  worktype2b |  -.4572821   .3717249    -1.23   0.219     -1.18585    .2712854
       _cons |   .0836193   1.168751     0.07   0.943    -2.207091     2.37433
-------------+----------------------------------------------------------------
caries2      |
         sex |   .2230848   .2482128     0.90   0.369    -.2634033    .7095729
       c_age |   .0038385   .0506798     0.08   0.940    -.0954921    .1031691
    hincome2 |  -.5376176   .3453608    -1.56   0.120    -1.214512    .1392772
 _Ip_educ3_1 |    .142542   .3843954     0.37   0.711    -.6108591    .8959431
 _Ip_educ3_2 |   .5455052   .5217742     1.05   0.296    -.4771533    1.568164
      c_dins |  -.2068218   .2697923    -0.77   0.443    -.7356049    .3219614
      p_hins |  -.4015735   .3336185    -1.20   0.229    -1.055454    .2523068
      stayw2 |  -.8690766   .4176161    -2.08   0.037    -1.687589   -.0505641
 p_bcountry2 |  -1.145966   .5222511    -2.19   0.028    -2.169559   -.1223727
       lang2 |  -.6852052   .5527173    -1.24   0.215    -1.768511    .3981007
  c_crossden |  -.2654567   .4752035    -0.56   0.576    -1.196838    .6659252
  c_medelig2 |  -.1478026   .3014993    -0.49   0.624    -.7387304    .4431251
  worktype2b |  -.1409218    .276491    -0.51   0.610    -.6828341    .4009905
       _cons |   1.730776   .9833752     1.76   0.078    -.1966043    3.658156
-------------+----------------------------------------------------------------
     /athrho |   .1292293    .190264     0.68   0.497    -.2436813    .5021399
-------------+----------------------------------------------------------------
         rho |   .1285147   .1871216                     -.2389699    .4637984
------------------------------------------------------------------------------
Likelihood-ratio test of rho=0:     chi2(1) =  .466996    Prob > chi2 = 0.4944
```

Glossary

AAP - American Academy of Periodontology - dedicated to advancing the art and science of periodontics and improving the periodontal health of the public. Membership consists of specialists in the prevention, diagnosis and treatment of diseases affecting the gums and supporting structures of the teeth and in the placement and maintenance of dental implants.

AAPD - American Academy of Pediatric Dentistry - dedicated to improving and maintaining the oral health of infants, children, adolescents, and persons with special health care needs.

Abscess - acute or chronic, localized inflammation associated with tissue destruction.

ADA - American Dental Association - promotes the public's health through commitment of member dentists to provide high-quality oral health care and promotes accessible oral health care for everyone. The organization also enhances the integrity and ethics of the profession by strengthening the patient/dentist relationship and providing services through its initiatives in education, research, advocacy and the development of standards.

Amalgam - an alloy used in direct dental restorations; a "silver filling."

Attrition - the normal wearing down of the surface of a tooth from chewing.

Baby bottle tooth decay - severe decay in baby teeth due to sleeping with a bottle of milk or juice. The drink's natural sugars combine with bacteria in the mouth to produce acid that decays teeth.

Bitewing Radiograph - x-rays of the top and bottom molars and pre-molars to show decay between teeth or under fillings.

Calculus - (tartar) hard deposit of mineralized material, or calcified plaque, that adheres to teeth.

Caries - tooth decay.

Cementum - hard connective tissue covering the tooth root.

CMS - Centers for Medicare and Medicaid Services - formally know as the Health Care Financing Administration (HCFA); a division of the Department of Health and Human Services (DHHS). The organization administers the Medicare, Medicaid, and Child Health Insurance Programs.

Covered services - service for which payment is provided under the terms of the dental benefit contract.

Crown - the artificial covering of a tooth with metal, porcelain or porcelain fused to metal; covers teeth that are weakened by decay or severely damaged or chipped.

Deciduous Dentition - refers to the deciduous or primary teeth in the dental arch.

Deciduous Teeth - baby teeth or primary teeth.

Dental Health Maintenance Organization (DHMO) - a benefit program in which enrollees receive all or most treatment through the dental office where they are enrolled. The dentist receives a single monthly payment from the benefits carrier for each enrolled patient, no matter how many services that patient receives.

Dentin - that part of the tooth that is beneath enamel and cementum.

Dentition - the teeth in the dental arch.

Denture - an artificial substitute for natural teeth and adjacent tissues.

DHHS/HHS - Department of Health and Human Services - federal department that oversees the federally funded programs that provide services such as prenatal screening, immunization, child care, nutrition, exercise, long-term care regulation and autopsies.

DPO - a dental benefit plan in which participating dentists agree to accept a list of specific fees as the total fees for dental treatment provided.

Eligible person - a person who is qualified to receive benefits under a dental benefit program.

Endentulous - having no teeth.

Endodontics - a dental specialty concerned with treatment of the root and nerve of the tooth. An endodontist is a dental specialist in this field.

Enrollee - a person who receives benefits under a dental benefit contract (also known as: beneficiary, covered person, insured, member).

ERISA - Employee Retirement Income Security Act of 1974 - administered by the Pension and Welfare Benefits Administration (PWBA) of the Department of Labor. The Act established new standards and reporting/disclosure requirements for employer-funded pension and health benefit programs in order to address public concern that funds of private pension plans were being mismanaged and abused.

Fee schedule - a list of the charges established or agreed to by a dentist for specific dental services.

Fee-for-service - a method of paying practitioners on a service-by-service rather than a "salaried basis."

Filling - a lay term used for the restoring of lost tooth structure by using materials such as metal, alloy, plastic or porcelain.

Fluoride - a chemical compound that prevents cavities; makes the tooth surface stronger so that teeth can resist decay.

General Anesthesia - a deep level of sedation in which patients lose consciousness, feel no pain, and have no memory of what is taking place around them.

Gingiva - soft tissues overlying the crowns of unerupted teeth and encircling the necks of those that have erupted.

Gingivitis - an inflammation of the gums surrounding the teeth caused by a buildup of plaque or food particles.

Halitosis - bad breath

Health Maintenance Organization (HMO) - a legal entity that accepts responsibility and financial risk for providing specified services to a defined population during a defined period of time at a fixed price.

HIAA - Health Insurance Association of America -advocate on behalf of the industry in the states and in the nation's capital.

HIPAA - Health Insurance Portability and Accountability Act of 1996 - the law's primary intent is to provide better access to health insurance, limit fraud and abuse, and reduce administrative costs through simplification.

HRSA - Health Resources Services Administration - a division of DHHS. The organization directs national health programs that improve the nation's health by assuring equitable access to comprehensive, quality health care for all.

Impacted Tooth - an unerupted or partially erupted tooth that is positioned against another tooth, bone, or soft tissue so that complete eruption is unlikely.

Implant - material inserted or grafted into tissue

Indemnity plan - a dental plan where a third-party payer provides payment of an amount for specific services, regardless of the actual charges made by the provider. Payment may be made either to enrollees or, by assignment, directly to dentists (e.g., schedule of allowances, table of allowances, or reasonable and customary plans).

Lesion - an injury or wound; area of diseased tissue.

Lingual - pertaining to or around the tongue; surface of the tooth directed toward the tongue; opposite of facial.

Malignant - having the properties of dysplasia, invasion, and metastasis

Malocclusion - improper alignment of biting or chewing surfaces of the upper and lower teeth.

Maximum allowance - the maximum dollar amount a dental program will pay toward the cost of a dental service as specified in the program's contract provisions.

Maximum benefit - the maximum dollar amount a program will pay toward the cost of dental care incurred by an individual or family in a specific time period (also known as: maximum allowable charge).

Maximum fee schedule - a compensation agreement in which a participating dentist agrees to accept a prescribed sum as the total fee for one or more covered services (also known as: maximum allowable reimbursement).

Molar - teeth posterior to the premolars (bicuspids) on either side of the jaw; grinding teeth, having large crowns and broad chewing surfaces

NADP - National Association of Dental Plans - a trade association that promotes and advances the HMO/PPO sector of the dental benefits industry to improve consumer access to affordable, quality dental care.

Network - a collective expression for all dentists who have contractually agreed to provide treatment according to administrative guidelines for a certain program.

NIDCR - National Institute of Dental and Craniofacial Research - promotes the general health of the American people by improving their oral, dental and craniofacial health.

NIH - National Institutes of Health - part of the U.S. Department of Health and Human Services. The organization conducts research; supports the research of non-Federal scientists in universities, medical schools, hospitals, and research institutions.

Occlusal - pertaining to the biting surfaces of the premolar and molar teeth or contacting surfaces of opposing teeth or opposing occlusion rims

Orthodontics - a dental specialty concerned with straightening or moving misaligned teeth and/or jaws with braces and/or surgery. An orthodontist is a dental specialist in this field.

Panoramic radiograph - a single large x-ray of the jaws taken by a machine that rotates around the head.

Pediatric Dentistry - a dental specialty concerned with treatment of children. A pediatric dentist is a dental specialist in this field (also known as: pedodontist).

Periodontics - a dental specialty concerned with treatment of gums, tissue and bone that supports the teeth. A periodontist is a dental specialist in this field.

Periodontitis - inflammation and loss of connective tissue of the supporting or surrounding structure of the teeth (also known as: gum disease).

Permanent Dentition - refers to the permanent teeth in the dental arch.

Plaque - a bacteria-containing substance that collects on the surface of teeth. Plaque can cause decay and gum irritation when it is not removed by daily brushing and flossing.

Point-of-service - arrangements in which patients with a managed care dental plan have the option of seeking treatment from an "out-of-network" provider. The reimbursement for the patient is usually based on a lower table of allowances with significantly reduced benefits than if the patient had selected an "in-network" provider.

Prevailing fee - the fee most commonly charged for a dental service in a given area.

Prophylaxis - a professional cleaning to remove plaque, calculus (mineralized plaque) and stains to help prevent dental disease.

Prosthesis - artificial replacement of any part of the body.

Prosthodontics - a dental specialty concerned with restoration and/or replacement of missing teeth with artificial materials. A prosthodontist is a dental specialist in this field.

Provider - a unique individual dentist (preferred providers, general dentists, specialty providers, practicing providers).

Pulp - connective tissue that contains blood vessels and nerve tissue which occupies the pulp cavity of a tooth

Radiograph - x-ray.

Reasonable and Customary (R & C) Plan - a dental benefit plan that determines benefits based only on "Reasonable and Customary" fee criteria.

Reasonable fee - the fee charged by a dentist for a specific dental procedure that has been modified by the nature and severity of the condition being treated and by any medical or dental complications or unusual circumstances. Therefore, it may differ from the dentist's "usual" fee or the benefit administrator's "customary" fee - removal of plaque, calculus, and stain from teeth.

Root - the anatomic portion of the tooth that is covered by cementum and is located in the alveolus (socket) where it is attached by the periodontal apparatus; radicular portion of tooth.

Root Canal - the portion of the pulp cavity inside the root of a tooth; the chamber within the root of the tooth that contains the pulp.

Scaling - removal of plaque, calculus, and stain from teeth.

SCHIP - State Children's Health Insurance Program - created from The Balanced Budget Act of 1997; expands health care coverage for children who are not covered by Medicaid.

Sealant - a thin plastic material used to cover the biting surface of a child's tooth to prevent tooth decay.

Usual fee - The fee that an individual dentist most frequently charges for a given dental service.

(Adapted from ADA - http://www.ada.org/public/resources/glossary.asp
and Delta Dental web sites http://www.deltadental.com/Public/OralHealth/dental_terms_af.jsp)

Bibliography/References

Adams TL. 2004. Attitudes to independent dental hygiene practice: dentists and hygienists in Ontario. *J Calif Dent Association*.;70(8):535-538.

Aday LA, Andersen R. 1974. A framework for the study of access to medical care. *Health Serv Res*.;9:208-220.

Ahovuo-Saloranta A, Hiiri A, Nordblad A, et al. 2004. Pit and fissure sealants for preventing dental decay in the permanent teeth of children and adolescents. *Cochrane Database of Systematic Reviews*.;3:CD001830

Albert DA, McManus JM, Mitchell DA. 2005. Models for delivering school-based dental care. *J Sch Health*.;75(5):157-161.

Allen PF. 2003. Assessment of oral health related quality of life. *Health and Quality of Life Outcomes.*1:40.

American Academy of Dental Pediatrics. 2005. Guideline on Periodicity of Examination, Preventive Dental Services, Anticipatory Guidance, and Oral Treatment for Children. Available at www.aapd.org.

American Association of Pediatric Dentistry. 2003. Policies on early childhood caries: Unique challenges and treatment option. Available at http://www.aapd.org/media/Policies_Guidelines/P_ECCUniqueChallenges.pdf

American Association of Pediatric Dentistry. 2003. Policies on early childhood caries: Unique challenges and treatment option. Available at http://www.aapd.org/media/Policies_Guidelines/P_ECCUniqueChallenges.pdf

American Association of Public Health Dentistry/American Board of Dental Public Health 1998. Competency statements for dental public health. *J Public Health Dent* 58(Suppl: 1):119-122

American Dental Association. 2006. *2005 Survey of Dental Fee*. Chicago, IL. Available at http://www.ada.org/prof/resources/pubs/adanews/adanewsarticle.asp?articleid=1988

American Family Physicians. 2002. Screening for depressions: recommendations and rationale. http://www.aafp.org/afp/20020815/usx.html

Andersen R, Lewis SZ, Giachello AL, Aday LA, Chiu G. 1981. Access to medical care among the Hispanic population of the Southwestern United States. *Journal of Health and Social Behavior.* 22(1):78-89.

Andersen RM . 1968. *Behavioral model of families' use of health services*. Research Series No. 25. Chicago, IL: Center for Health Administration Studies, University of Chicago.

Andersen RM . 1995. Revisiting the behavioral model and access to medical care: Does it matter? *Hlth Social Behav* 36(March):l-10

Andersen RM, Davidson PL, Nakazono TT. 1997. Oral health policy and programmatic implications: Lessons from ICS-II. *Adv Dent Res*. 11(2):291-303.

Andersen RM, Davidson PL. 1997. Ethnicity, aging, and oral health outcomes: A conceptual framework. *Adv Dent Res*. 11(2):203-209.

Annie Casey Foundation 2005. *Border kids count pocket guide: A snapshot of children living on the southwest border*.

Arendt JN, Holm A. 2006. Probit models with binary endogenous regressors. Discussion Papers on Business and Economics. No. 4/2006. University of Southern Denmark.

Arrow K. 1963. Uncertainty and the Welfare Economics of Medical Care. *The American Economic Review* 53(5):940-73

Astroth DB, Cross-Poline GN. 1998. Pilot study of six Colorado dental hygiene independent practices. *J Dent Hyg*. 72(1):13-22.

Atkins D, Eccles M, Flottorp S, et al. 2004. Systems for grading the quality of evidence and the strength of recommendations I: Critical appraisal of existing approaches The GRADE Working Group. BMC Health Services Research 38:4-11.

Axelsson P, Paulander J, Svardstrom G,Tollskog G,Nordensten S. 1993. Integrated caries prevention: effect of a needs-related preventive program on dental caries in children. County of Varmland, Sweden: results after 12 years. *Caries Res*. 27 Suppl 1:83-94.

Axelsson P. 1999. *An Introduction To Risk Reduction And Preventive Dentistry*. Quintessence Publishing Co. Inc. Chicago, IL.

Axelsson, P., ed., 2002. *Diagnosis and Risk Prediction of Periodontal Diseases*. The Axelsson Series on Preventive Dentistry. Chicago: Quintessence books

Bagramian RA. 1982. A 5-year school-based comprehensive preventive program in Michigan, U.S.A. *Community Dent Oral Epidemiol* 10:234–7. (SB)

Baum CF, Schaffer ME, Stillman S. 2003. Instrumental variables and GMM: Estimation and Testing. Boston College. Working Paper No. 545. http://fmwww.bc.edu/EC-P/WP545.pdf

Baum CF. 2006. *An Introduction to Modern Econometrics Using STATA.* College Station:Stata Press.

Beck JD. Offenbacker S. 1998. Oral health and systemic disease: periodontitis and cardiovascular disease. *J Dent Educ.* 62:859-870.

Bloom B, Gift HC, Jack SS. 1992. Dental services and oral health. *Vital Health Stat* 10. 183:1-95.

Bravo M, Baca P, Llodra JC, Osorio E. 1997. A 24-month study comparing sealant and fluoride varnish in caries reduction on different permanent first molar surfaces. *J Public Health Dent* 57:184–6. (SB)

Brennan DS, Spencer AJ. 2006. Mapping oral health related quality of life to generic health state values. *BMC Health Services Research*. 6:96.

Brown E, Manski R. 2004. *Dental services: use, expenses, and sources of payment, 1996-2000*. Rockville, MD: Agency for Healthcare Research and Quality; MEPS Research Findings No. 20. AHRQ Pub No. 04-0018.

Brown LJ, Kaste LM, Selwitz RH, Furman LJ. 1996. Dental caries and sealant usage in US children 1988-91: selected findings from the Third National Health and Nutrition Examination Survey. *JADA* 127:335-343.

Burt BA, Berman DS, Silverstone LM. 1977. Sealant retention and effects on occlusal caries after 2 years in a public program. *Community Dent Oral Epidemiol* 5:15–21.

Burt BA. 1998. Prevention policies in light of the changed distribution of dental caries. *Acta Odontol Scand* 56:179-186.

Calderone JJ, Mueller LA. 1983. The cost of sealant application in a state dental disease prevention program. *J Public Health Dentistry*. 43(3):249-254.

Cappellari L, Jenkins SP. 2003. MVPROBIT: Stata module to calculate multivariate probit regression using simulated maximum likelihood. Revised 2006. http://ideas.repec.org/c/boc/bocode/s432601.html.

Cappelli DP. 2004. Health Surveillance in Texas. Texas Oral Health Summit: Advocacy, Equity and Access. Austin, Texas. September 9-10.

Casamassimo PS. 2003. Dental disease prevalence, prevention, and health promotion: the implications on pediatric oral health of a more diverse populations. *Pediatr Dent*. 25(1):16-8

Catalanotto F. 2006. Flaws of the Medicaid system that make it so difficult for dentists to participate. *J Am Coll Dent*.73(2):5-6

Catlin A, Cowan C, Heffler S, Washington B. 2007. National health spending in 2005: The slowdown continues. *Health Affairs.* 26(1):142-153.

Centers for Disease Control and Prevention. 2007. Oral Health: Preventing Cavities, Gum Disease, and Tooth Loss. Available at http://www.cdc.gov/nccdphp/ publications/aag/oh.htm. Accessed April 6, 2007.

Centers for Disease Control and Prevention 1993. Fluoridation Census 1992: Summary. Atlanta, GA: US Dept of Health and Human Services, Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. 2005. Disparities in Oral Health. http://0-www.cdc.gov.mill1.sjlibrary.org/nchs/data/hp2000/oralhealth/ disparitytables.pdf.

Center for Health and Social Policy. 2003. Health workforce needs: opportunities for U.S.-Mexico collaborations. 2003 proceedings and background papers.

Centers for Disease Control and Prevention. 2001. Impact of targeted, school-based dental sealant programs in reducing racial and economic disparities in sealant prevalence among school children – Ohio, 1998-1999. *MMWR Weekly*.2001;50(34):736-738.

Centers for Disease Control and Prevention. 2004.Health Disparities Experienced by Hispanics. *MMWR Weekly*. 53(40);935-937

Centers for Disease Control and Prevention. 2005. Preventing Dental Caries. Available at http://www.cdc.gov/nccdphp/publications/factsheets/Prevention/oh.htm

Centers for Disease Control and Prevention. 2005. Surveillance for Dental Caries, Dental Sealants, Tooth Retention, Eduntulism and Enamel Fluorosis – United States, 1988-94 and 1999-2002. *MMWR.* 54(S-3).

Chang SW, Plotkin DR, Mulligan R, Polido JC, Mah JK, Meara JG. 2003. Teledentistry in rural California: A USC initiative. *J Calif Dent Assoc*. 31(8):601-608.

Clark GT. 2000. Teledentistry: what is it now, and what will it be tomorrow? *J Calif Dent Association*. 28(2):121-7.

Cochrane AL. 1972. *Effectiveness and Efficiency. Random Reflections on Health Services*. London: Nuffield Provincial Hospitals Trust.

Cohen LK, Bailit HL, Barmes DE. 1987. International Collaborative Study of Oral Health Outcomes. *International Sociology* 2(4):419-426.

Cook J, Mullings C, Vowles R, Stephens C. 2002. The use of teledentistry to provide GDPs with advice in orthodontics. *Dent Update*.;29(5):249-55

Dasanayake AP, Li Y, Kirk K, Bronstein J, Childers NK. 2003. Restorative cost savings related to dental sealants in Alabama Medicaid children. *Pediatr Dent* 25(6):572-6.

Dasanayake AP. 1998. Poor periodontal health of the pregnant woman at a risk factor for low birth weight. *Ann Periodontol.* 3:161-174

Davies HTO, Nutley SM, Smith PC. 2001. *What works? Evidence-based policy and practice in public services*. Bristol: Policy Press.

de Oliveira BH, Nadanovsky P. 2006. The impact of oral pain on quality of life during pregnancy in low-income Brazilian women. *J Orofac Pain*.;20(4):297-305

Deery C. 1999. The economic evaluation of pit and fissure sealants. *International Journal of Paediatric Dentistry.* 9:235-241.

Department of Health and Human Services. 2007. Preventing chronic disease: Investing wisely in health. Preventing dental caries. http://www.cdc.gov/nccdphp/publications/factsheets/Prevention/pdf/oh.pdf. Accessed January 25, 2007.

Department of State Health Services. 2007. Health Disparities Task Force. *Health Disparities in Texas*. Annual Report 2004. DSHS. Available at http://www.dshs.state.tx.us/oehd/hdtf/pdf/HDTF2004AnnualReport.pdf. Accessed January 25, 2007

Department of State Health Services. *Texas Health Facts* Data Sources, 2002. February 2006. Available at http://www.dshs.state.tx.us/borderhealth/pdf/2002_county_facts/Willacy2002.pdf. Accessed January 25, 2007

Dunning, JM. 1986.*Principles Of Dental Public Health*. 4th ed. London: Harvard University Press.

Easton D. 1965. *Systems Analysis of Political Life*. Chicago, IL: University of Chicago Press.

Edelstein BL, Douglass CW. 1995. Dispelling the myth that 50 percent of U.S. schoolchildren have never had a cavity. *Public Health Rep* September;110(5):522-30.

Edelstein BL. 2002. Disparities in oral health and access to care: findings of national surveys. *Ambul Pediatr* 2(2 Suppl):141-7.

Epstein SE, Zhou YF, Zhu J. 1999. Infection and atherosclerosis: emerging mechanistic paradigms. *Circulation.* 100:E20-E28.

Ersin NK, Eronat N, Cogulu D, Uzel A, Aksit S. 2006. Association of maternal-child characteristics as a factor in early childhood caries and salivary bacterial counts. *J Dent Child* (Chic). 73(2):105-11.

Estrada AL, Trevino FM, Ray LA. 1990. Health care utilization barriers among Mexican Americans: evidence from HHANES 1982-84. *Am J Public Health* 1990;80(Suppl):27-31.

Featherstone JD, et al. 2003. Caries management by risk assessment: consensus statement. *J Calif Dent Assoc* 31:257-69

Federal Poverty Guidelines. 007. *Federal Register*, Vol. 72, No. 15, January 24, 2007, pp. 3147–3148 http://aspe.hhs.gov/poverty/07poverty.shtml

Feldstein, M. 1963. "Economic analysis, operational research, and the national health service" *Oxford Economic Papers* 15 (March):19-31.

Felkner M, Suarez L, Hendricks K, Larsen R. 2005. Implementation and outcomes of recommended folic acid supplementation in Mexican-American women with prior neural tube defect-affected pregnancies. *Prev Med*. 40(6):867-71.

Finlay L. 2002. "Outing" the researcher: the provenance, process and practice of reflexivity. *Qualitative Health Research*. 12(4):531-545.

Fisher MA, Gilbert GH, Shelton BJ. 2004. A cohort study found racial differences in dental insurance, utilization and the effect of care on quality of life. *Journal of Clinical Epidemiology*. 57:853-857

Flores G, Bauchner H, Feinstein AR, Nguyen UDT. 1999. The impact of ethnicity, family income, and parental education on children's health and use of health services. *Am J Pub Health.* 89(7):1066-1071.

Flores G, Fuentes-Affleck E, Barbot O et al. 2002. The Health of Latina Children: Urgent priorities, unanswered questions, and a research agenda. *JAMA* 288(1):82-90.

Folke BD, Walton JL, Feigal RJ. 2004. Occlusal sealant success over ten years in a private practice: comparing longevity of sealants placed by dentists, hygienists, and assistants. *Pediatr Dent.* 26(5):246-232.

Folke LE. 2001. Teledentistry: An Overview. *Tex Dent J.* 118(1):10-18

Fourrier F, Duvivier B, Boutigny H, Roussel-Delvallez M, Chopin C. 1998. Colonization of dental plaque: a source of nosocomial infections in intensive care unit patients. *Crit Care Med.*26:301-308.

Fox RI, Tornwall J, Maruyama T, Stem M. 1998. Evolving concepts of diagnosis pathogenesis and therapy of Sjögren's syndrome. *Curr Opin Rheumatol.* 10:446-456.

Friedman L, Mackler IG, Hoggard GH, French CI. 1976. A comparison of perceived and actual dental needs of a select group of children in Texas. *Community Dent Oral Epidemiol*. 4(3):89-93.

General Accounting Office. 2000. *Oral health: dental disease is a chronic problem among low-income populations.* Report GAO/HEHS-00-72. http://www.gao.gov.

Garcia JA, Juarez RZ. 1978. Utilization of dental health services by Chicanos and Anglos. *Journal of Health & Social Behavior*. 19, 428-436.

Gift HC. 1977. The dental patient's culture response to the need for dental care. *Dent Clin North Am* 21:595-604.

Ginsburg PB, Strunk BC, Banker MI, Cookson JP. 2006. Tracking health care costs: Continued stability but at high rates in 2005. *Health Affairs*. 25(6):w486-w495.

Glock, Martha; Horowitz, Alice M.; Canto, Maria T., compilers. 2000. Diagnosis and management of dental caries. January 1980 through CBM2001-1. National Library of Medicine. February 2001.

Golder DT, Brennan KA. 2000. Practicing dentistry in the age of telemedicine. *J Am Dent Assoc*. 131(6):734-744.

Gooch BF, Truman BI, Griffin SO, et al. 2002. A comparison of selected evidence reviews and recommendations on interventions to prevent dental caries, oral and pharyngeal cancers, and sport-related craniofacial injuries. *Am J Prev Med.* 23(1S):55-80.

Goozner M. 2007. Toothache gone wrong. *The Guardian*. February 28, 2007. http://commentisfree.guardian.co.uk/merrill_goozner/2007/02/toothache_gone_wrong.html . Accessed January 25, 2007

Gordon-Larsen P, Harris KM, Ward DS, Popkin BM; 2003. National Longitudinal Study of Adolescent Health. Acculturation and overweight-related behaviors among Hispanic immigrants to the US: the National Longitudinal Study of Adolescent Health. *Soc Sci Med*. 57(11):2023-34.

Grau AJ. Buggie F. Ziegler C, et al. 1997. Association between cerebrovascular ischemia and chronic and recurrent infection. *Stroke.* 28:1724-1729.

Griebsch I, Coast J, Brown J. 2005. Quality-Adjusted Life-Years lack quality in pediatric care: A critical review of published cost-utility studies in child health. *Pediatrics*. 115:e600-e614.

Griffin SO, Griffin PM, Gooch BF, Barker LK. 2002. Comparing the costs of three sealant delivery strategies. *J Dent Res*. 81(9):641-645.

Guendelman S. 1991. Health care users residing on the Mexican border. What factors determine choice of the US or Mexican health care system? *Med Care*, 29(5):19-29.

Gujarati D. 2003. *Basic Econometrics*. 4th edition. Tata- McGraw Hill.

Hahn RA, Mulinare J, Teutsch SM. 1992. Inconsistencies in coding of race and ethnicity between birth and death in US infants. A new look at infant mortality, 1983 through 1985. *JAMA* 267:259-263.

Halstrom W. 2007. Let’s put the mouth back in the body. *Canadian Medical Association Journal*. 17(2):145.

Harris R, Nicoll AD, Adair PM, Pine CM. 2004. Risk factors for dental caries in young children: a systematic review of the literature. *Community Dental Health*. 21(S):71-85.

Hayashi F. 2000. *Econometrics.* Princeton, NJ:Princeton University Press. p.233

Hayes-Bautista DE, Kahramanian MI, Richardson EG, Hsu P, Sosa L, Gamboa C, Stein RM. 2007. The rise and fall of the latino dentist supply in California: implications for dental education. *J Dent Educ*. 71(2):227-34.

Hayward RA, Meetz HK, Shapiro MF, Freeman HE. 1989. Utilization of dental services: 1986 patterns and trends. *Publ Hlth Dent* 49:147-152.

Heckman JJ. 1978. Dummy endogenous variables in a simultaneous equation system. *Econometrica*. 46(4):931-959.

Holtman AG, Olsen, EO, Jr. 1976. The demand for dental care: A study of consumption and household production. *The Journal of Human Resources*. 11(4). 546-560.

Horowitz HS, Heifetz SB, Poulsen S. 1977. Retention and effectiveness of a single application of an adhesive sealant in preventing occlusal caries: final report after five years of a study in Kalispell, Montana. *J Am Dent Assoc.* 95:1133–9. (SB)

Hughes RJ, Damiano PC, Kanellis MJ, Kuthy R, Slayton R. 2005. Dentists' participation and children's use of services in the Indiana dental Medicaid program and SCHIP: assessing the impact of increased fees and administrative changes. *J Am Dent Assoc*. 136(4):517-523.

Hurley J. 2001. An Overview of the Normative Economics of Health Sector. In Culyer & Newhouse, eds. *Handbook of Health Economics*. New York: Elsevier.

Institute of Medicine. 1988. *The Future of Public Health*. Committee for the Study of the Future of Public Health. Washington DC: National Academy Press.

Ismail AI, King W, Clark DC. 1989. An evaluation of the Saskatchewan pit and fissure sealant program: a longitudinal follow up. *J Public Health Dent* 49(4):206-11. Available from: PubMed; PMID 2810215

Ismail AI, Szpunar SM. 1990. The prevalence of tooth loss, dental caries, and periodontal disease among Mexican Americans, Cuban Americans, and Puerto Ricans: Findings from NHANES 1982-1984. *Am J Publ Hlth* 80(Suppl):66-70.

Ismail AI, Szpunar SM. 1990. Oral health status of Mexican-Americans with low and high acculturation status: findings from southwestern HHANES, 1982-84. *J Public Health Dent.* 50(1):24–31.Winter

Ismail AI. 2003. Determinants of health in children and the problem of early childhood caries. *Pediatr Dent*.;25(4):328-333.

Jackson DM, Jhanke LR, Kerber L, Nyer G, Siemens K, Clark C. 2007. Creating a successful school-based mobile dental program. *J School Health*. 77(1):1-6.

Johnston JA. 1993. Improving utilization of dental services by understanding cultural difference. *Int Dent J* 43:506-511.

Jones JA, Fedele DJ, Bolden AJ, Bloom B. 1994. Gains in dental care use not shared by minority elders. *Publ Hlth Dent* 54:39-46.

Journal of American Dental Association. 2006. Healthy mouth, healthy body. 137

Kaiser Network. 2003. Daily Health Reports: Nation facing shortage of dentists. Sep 22, 2003. http://www.kaisernetwork.org/daily_reports/rep_index.cfm?DR_ID=19943 Accessed March 7, 2007

Kaste LM, Selwitz RH, Oldakowski JA, Brunelle JA,Winn DM, Brown LJ. 1996. Coronal caries in the primary and permanent dentition of children and adolescents 1-17 years of age: United States, 1988-1991. *J Dent Res.* 75(special issue):631-641.

Kenney GM, Ko G, Ormond BA. 2000. Gaps in prevention and treatment: Dental care for low-income children. The Urban Institute. Series B, No. B-15. http://www.urban.org/UploadedPDF/b15.pdf. Accessed May 25, 2007

Kenney GM, McFeeters JR, Yee JY. 2005. Preventive dental care and unmet dental needs among low-income children. *Am J Pub Health*. 95(8):1360-1366

Kernick DP. 1998. Has health economics lost its way? *BMJ*. 317:197-199.

Kidd EA, et al. 2004. What constitute dental caries?...*J Dent Res* 83:C35-8.

Kim YOR. 2005. Reducing disparities in dental care for low-income Hispanic children. *J Health Care for the Poor and Underserved.* 16:431-443.

Klein SP, Bohannan HM, Bell RM, Disney JA, Foch CB, Graves RC. 1985. The cost and effectiveness of school-based preventive dental care. *Am J Public Health* 75:382–91. (SB)

Knapp KK, Hardwick K. 2000. The availability and distribution of dentists in rural ZIP codes and primary care health professional shortage areas (PC-HPSA) ZIP codes: comparison with primary care providers. *J Public Health Dent*. 60(1):43-48.

Kuh D, Ben-Shlomo Y. 2004. *A life course approach to chronic disease epidemiology*, (No. Ed.2) xix + 473 pp.

Kumar JV, Davila ME, Green EL, Lininger LL. 1997. Evaluation of a school-based sealant program in New York State. *J Public Health Manag Pract* 3(3):43-51. Available from: PubMed; PMID 10186723

Last JM. 1998. *Public Health and Human Ecology*. 2nd ed. McGraw Hill Professional. p. 464.

Leverett DH, Brenner CM, Handelman SI, Iker HP. 1983. Use of sealants in the prevention and early treatment of carious lesions: cost analysis. *Journal of American Dental Association*. 106:39-42.

Levy BS, Sidel VW (eds.) 2006. *Social Injustice and Public Health*. New York: Oxford University Press.

Lewis CW, Johnston BD, Linsenmeyar KA, Williams A, Mouradian W. 2007. Preventive Dental Care for Children in the United States: A National Perspective. *Pediatrics* 119;544-553.

Liu J, Probst JP, Martin AB, Wang J, Salinas CF. 2007. Disparities in dental insurance coverage and dental care among US children: The National Survey of Children's Health. *Pediatrics*. 119:12-21.

Llodra JC, Bravo M, Delgado-Rodriguez M, et al. 1993. Factors influencing the effectiveness of sealants – a meta-analysis. *Community Dent Oral Epidemiol*. 21(5):261-8.

Long JS, Freese J. 2006. *Regression Models for Categorical Dependent Variables Using Stata*. 2nd ed. College Station, TX: Stata Press Publications.

Macek MD, Manski RJ, Vargas CM, Moeller JF. 2002. Comparing oral health care utilization estimates in the United States across three nationally representative surveys. *Health Services Research*. 27(2):499-521.

Macias EP, Morales LS. 2001. Crossing the border for health care. *J Health Care Poor Underserved*. 12(1):77-87.

Maddala, GS. 1983. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge University Press. Cambridge.

Mandall NA, O'Brien KD, Brady J, Worthington HV, Harvey L. 2005. Teledentistry for screening new patient orthodontic referrals. Part 1: A randomised controlled trial. *Br Dent J*. 199(10):659-62, discussion 653.

Manning WG, Jr., Phelps CE. 1970. The demand for dental care. *Bell Journal of Economics*.

Manski RJ, Macek MD, Moeller JF. 2002. Private dental coverage: who has it and how does it influence dental visits and expenditures. *J Am Dent Assoc* 133(11):1551-1559.

Manski JM, Moeller JF, Maas WR. 2001. Dental services: An analysis of utilization over 20 years. *J Am Dent Assoc* 132:655-664

Manski RJ, Eldestein BL, Moeller JF. 1996. The impact of insurance coverage on children dental visits and expenditures, *J Am Dent Assoc* 2001;132(8):1137-45

Manski RJ, Macek MD, Moeller JF. 2002. Private dental coverage: who has it and how dies it influence dental visits and expenditures? *J Am Dent Assoc* 133:1551-1559.

McColl E, Jacoby A, Thomas L, Soutter J, Manford C, Steen N, et al. 2001. The Conduct and Design of Questionnaire Surveys in Healthcare Research. In Stevens et al. Eds. *The Advanced Handbook of Methods in Evidence Based Healthcare.* London: Sage Publications

McCune RJ, Bojanini J, Abodeely RA. 1979. Effectiveness of a pit and fissure sealant in the prevention of caries: three-year clinical results. *J Am Dent Assoc* 99:619–23.

McLaurin JA. 1999. Health care for children of migrant farm workers. In: Green M, Haggerty R, Weitzman M. eds. *Ambulatory Pediatrics*. 5th ed. Philadelphia, Pa; WB Saunders; 524-529

Messer LB, Calache H, Morgan MV. 1997. The retention of pit and fissure sealants placed in primary school children by Dental Health Services, Victoria. *Aust Dent J* 42:233–9.

Mindel CH, Habenstein RW. 1981. *Ethnic families in America, patterns and variations*. Amsterdam: Elsevier Science Publishers BV.

Monfardini, C, Radice, R. 2006. Testing Exogeneity in the Bivariate Probit Model: A Monte Carlo Study (March 10, 2006). Available at SSRN: http://ssrn.com/abstract=886506. Accessed April 11, 2007

Moore DS. 1978. The significance, importance, and method of determining the dental IQ of a patient. *Dent J.* 44(8):367-8.

Morey DP, Leung JJ. 1993. The multicultural knowledge of registered dental hygienists: A pilot study. / *Dent Hygiene* 67(4): 180-185.

Morgan MV, Campain AC, Crowley SJ, Wright FA. 1997. An evaluation of a primary preventive dental programme in non-fluoridated areas of Victoria, Australia. *Aust Dent J* 42:381–8.

Morreale et al. 2005. Setting up a mobile dental clinic within your present office structure. *J Can Dent Assoc,* 71(2):91.

Mouradian WE, Wehr E, Crall JJ. 2000. Disparities in children's oral health and access to dental care. *JAMA* 284(20):2625-2631.

National Library of Medicine. 2001. *Diagnosis and Management of Dental Caries Throughout Life*. NIH Consensus Statement Online 2001 March 26-28;18(1): 1-30. caries [bibliography on the Internet]. Bethesda (MD): National Library of Medicine (US). (Current bibliographies in medicine; no. 2001-1). 1592 citations from January 1980 through December 2000. Available from: http://www.nlm.nih.gov/pubs/cbm/dental_caries.pdf. Accessed March 7, 2007

National Campaign for the Prevention of Teen Pregnancy. 2007. Available at http://www.teenpregnancy.org/america/statisticsDisplay.asp?ID=3&sID=23. Accessed January 11, 2007.

Newacheck PA, Brindis CD, Cart CU, et al. 1999. Adolescent health insurance coverage: recent changes and access to care. *Pediatrics*. 104-195-202.

Niessen LC, Douglass CW. 1984. Theoretical considerations in applying benefit-cost and cost-effectiveness analyses to preventive dental programs. *J Public Health Dent* 44:156–68

Nolan L, Kamoie B, Harvey J, Vaquerano L, Blake S, Shawla S, Levi J and Rosenbaum. 2003. The effects of state dental practice laws allowing alternative models of preventive oral health care delivery to low-income children. Washington DC: The George Washington University Medical Center. 2003.

Nord E. 1999.*Cost-Value Analysis in Health Care: Making Sense Out Of Qalys*. Cambridge, UK:Cambridge University Press.

Offenbacher S, Katz V, Fertik G, et al. 1996. Periodontal disease as a possible risk factor for preterm low bith weight. *J Periodontol.* 67:1103-1113.

Oscarson N, Kallestal C, Lindholm L. 2007. A pilot study of the use of oral health-related quality of life measures as an outcome for anlysing the impact of caries disease among Swedish 19-year-olds. *Caries Res.* 41(2):85-92.

Oscarson N, Lindholm L, Kallestal C. 2007. The value of caries preventive care among 19-year olds using the contingent valuation method within a cost-benefit approach. *Comm Dent Oral Epidemiol*. 35:109-117

Otto M. 2007. For want of a dentist. *Washington Post*. February 28, 2007. Page B01.

Perkins JL, Zavaleta AN, Mudd G, Bollinger M, Muihead Y, Cisneros J. October 2001. The Lower Rio Grande Valley Community Health Assessment. The University of Texas Health Science Center at Houston. Available at http://www.sph.uth.tmc.edu/uploadedFiles/Regional_Campuses/Brownsville/LRGV_ASSESSMENT.pdf. Accessed June 7, 2007.

Pitts NB. 2001. Clinical Diagnosis of dental caries: A European perspective. *J Dent Edu.* 65(10):972.

Quandt SA, Hiott AE, Grzywacz JG, Davis SW, Arcury TA. 2007. Oral health and quality of life of migrant and seasonal farmworkers in North Carolina. *J Agric Saf Health*. 13(1):45-55

Ramirez RB. Hispanic population in the United States:1999 Mar CPS. US Bureau of the Census. Available at http://www.census.gov/population/www/socdemo/hispanic/ho99.html. Accessed February 28, 2007

Ramos-Gomez FJ, et al. 2002. Bacterial, behavioral, and environmental factors associated with early childhood caries. *J Clin Pediatr Dent*. 26:165-73

Ramos-Gomez FJ, Tomar SL, Ellison J, Artiga N, Sintes J, Vicuna G. 1999. Assessment of early childhood caries and dietary habits in a population of migrant Hispanic children in Stockton, California. *ASDC J Dent Child* 66(6):395-403, 366. Available from: PubMed; PMID 10656122

Rea LM, Parker, RP. 1997. *Designing and Conducting Survey Research*. San Francisco, CA: Jossey-Bass Publisher.

Redmond AR, Martin N. 2006. Provision of school-based preventive oral health services to Medicaid beneficiaries. Prev Chronic Dis. [serial online]. Available: http://www.cdc.gov/pcd/issues/2006/jan/05_0036.htm. Accessed January 11, 2007

Rhoades, JA. June 2005. *The Uninsured in America, 2004: Estimates for the U.S. Civilian Noninstitutionalized Population under Age 65.* Statistical Brief #83. Agency for Healthcare Research and Quality, Rockville, Md. http://www.meps.ahrq.gov/papers/st83/stat83.pdf

Rice, T. 1998. *The Economics of Health Reconsidered.* Health Administration Press: Chicago

Ripa, LW, Leske GL, Sposato A. 1985. The surface-specific caries pattern of participants in a school-based fluoride mouthrinsing program with implications for the use of sealants. *J Pub Health Dent.* 45:90-94.

Ryan J. 2003. Improving oral health: promise and prospects. National Health Policy Forum Background Paper. Washington DC:George Washington University.

Sackett DL, Rosenberg WMC, Gray JAM, et al. 1996. Evidence-based medicine: what it is and what it isn't. *BMJ*;312:71-72 (13 January)

Scheie A. 1994. Mechanisms of dental plaque formation. *Adv Dent Res*. 8:246-253

Scuffham PA, Steed M. 2002. An economic evaluation of the Highlands and Islands teledentistry project. *J Telemed Telecare*. 8(3):165-77

Seale NS, Casamassimo PS. 2003. Access to dental care for children in the United States: a survey of general practitioners. *J Am Dent Assoc*. 134(12):1630-40.

Segal MD, Farquhar CL, Bouchard JM. 1997. Dental Sealants. *Pub Health Rep*. 112:99-108.

Selwitz RH, Ismail AI, Pitts NB. 2007. Dental caries. *Lancet* 369(9555):51-9

Selwitz RH, Nowjack-Raymer R, Driscoll WS, Li SH. 1995. Evaluation after 4 years of the combined use of fluoride and dental sealants. *Community Dent Oral Epidemiol* 23:30–5. (SB)

Sheiham SA. 2006. Dental caries affects body weight, growth and quality of life in pre-school children. *Br Dent J*. 201(10):625-6.

Slavkin HC, BJ Baum. 2000. Relationship of dental and oral pathology to systemic illness. *JAMA*. 284(10):1215-1217.

Songpaisan Y, Bratthall D, Phantumvanit P, Somridhivej Y. 1995. Effects of glass ionomer cement, resin-based pit and fissure sealant and HF applications on occlusal caries in a developing country field trial. *Community Dent Oral Epidemiol* 23:25–9. (SB)

Stanton MW, Rutherford MK. 2003. *Dental Care: Improving Access and Quality*. Rockville, MD: Agency for Healthcare Research and Quality. Research in Action Issue #13. AHRQ Pub No. 03-0040.

State of California, Department of Finance. 2007. County Population Projections with Age, Sex, and Race. Ethnic Detail. July 1, 1990-2040. http://www.dof.ca.gov/html/Demograp/projca.pdf. Accessed June 3, 2007

Stephens C, Cook J, Mullings C. 2002. Orthodontic referrals via TeleDent Southwest. *Dent Clin North Am*. 46(3):507-20

Sterritt GR, Frew RA, Rozier RG. 1994. Evaluation of Guamanian dental caries preventive programs after 13 years. *J Public Health Dent* 54:153–9

Sun WY, Wu JS. 1997. Comparison of dietary self-efficacy and behavior among American-born and foreign-born Chinese adolescents residing in New York City and Chinese adolescents in Guangzhou, China. . *J Am Coll Nutr*. 16(2):127-33.

Swank ME, Vernon SW, Lairson DR. 1986. Patterns of dental preventive behavior. *Pub Health Reports*. 101(2):175-184.

Testa MA, Simonson DC. Assessment of Quality-of-Life outcomes. 1996. *N Engl J Med*. 334(13):835-840.

Texas Comptroller of Public Accounts. 2001. The Border: On the brink. Available at http://www.cpa.state.tx.us/specialrpt/brink. Accessed January 25, 2007

Texas Department of Health. 2002. http://www.dshs.state.tx.us/borderhealth/pdf/2002_county_facts/Willacy2002.pdf. Accessed March 7, 2007.

Texas Health Education Coordinating Board (THECB). 2004. Texas Mexico Health Education Needs. Report to 77th Legislature. http://www.dshs.state.tx.us/borderhealth/pdf/TxMx_BorderHealthEducationNeeds_0295.pdf. Accessed April 6, 2007.

Texas School Performance Review. 2002. Available at http://www.window.state.tx.us/tspr/lyford/ch02c2.htm. Accessed on April 29, 2007.

Texas Senate Committee on Border Health. 2000. *Border Health: A Binational Concern*. 76th Legislature Interim.

The Guide to Community Preventive Services. July 2002. Population-based measures to reduce dental caries. Economic evidence summary table. Available at ww.thecommunityguide.org.

Tinanoff N, Palmer CA. 2000. Dietary determinants of dental caries and dietary recommendations for preschool children.*J Public Health Dent*. 60(3):197-206; discussion 207-9.

Truman. Task Force on Community Preventive Services. 2002. Recommendations on selected interventions to prevent dental caries, oral and pharyngeal cancers, and sport-related craniofacial injuries. *Am J Prev Med* 23(1 Suppl):16–20.

US Department of Health and Human Services. 2000. *Oral Health in America: A Report of the Surgeon General*. Rockville, MD: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health.

U.S. Department of Health and Human Services. November 2000. *Healthy People 2010*. 2nd ed. With Understanding and Improving Health and Objectives for Improving Health. 2 vols. Washington, DC: U.S. Government Printing Office, http://www.healthypeople.gov/Document/tableofcontents.htm#volume2

U.S. Department of Health and Human Services. 2003. *A National Call to Action to Promote Oral Health.* Rockville, MD: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institutes of Health, National Institute of Dental and Craniofacial Research. NIH Publication No. 03-5303, http://www.nidcr.nih.gov/AboutNIDCR/SurgeonGeneral/NationalCallToAction.htm. Accessed April 29, 2007.

United States General Accounting Office. April 2000. Oral Health: Dental disease is a chronic problem among low-income populations. Report to Congressional Requestors. GAO-HEHS 00-72

US Census Bureau. 2000. www.census.gov. Accessed June 8, 2007.

US General Accounting Office. 2000. Dental Disease is a chronic problem among low-income populations.

US Inspector General. 1996. Children's *Dental Services Under Medicaid: Access and Utilization*. San Francisco, CA:US Department of Health and Human Services; Publication OEI 09-93-00240.

Valdez AS, Baker J, Bartlett RP, et al. 2004. Health Disparities in Texas. Health Disparities Task Force. Annual Report 2004. Available at http://www.dshs.state.tx.us/oehd/hdtf/pdf/HDTF2004AnnualReport.pdf. Accessed April 29, 2007.

Valtonen VV. 1999. Role of infections in atherosclerosis. *Am Heart J.* 138:5431-5433.

van den Hout WB, Tijhuis GJ, Hazes JMW, Breedveld FC, Vliet Vlieland TPM. 2003. Cost effectiveness and cost utility analysis of multidisciplinary care in patients with rheumatoid arthritis: a randomized comparison of clinical nurse specialist care, inpatient team care, and day patient team care. *Annals of the Rheumatic Diseases* 62(4):308-316

Vargas CM, Ronzio CR. 2002. Relationship between children's dental needs and dental care utilization: United States, 1988-94. *Am J Public Health*. 92:1816-1821

Vazquez L, Swan JH. 2003. Access and attitudes toward oral health care among Hispanics in Wichita, Kansas. *J Dent Hyg* 77(2):85-96.

Waldman HB. 1998. More children are unable to get dental care than any other single health service. *J Dent Child.* 65:204-208

Warner DC, Jhanke LR. April 2003. *US/Mexico Border Health Issues: The Texas Rio Grande Valley*. Regional Center for Health Workforce Studies. The University of Texas Health Science Center at San Antonio.

Warren RC. 1990. Oral health for the poor and underserved. *J Health Care Poor Underserved* 1990 Summer;1(1):169-80. Comment in: *J Health Care Poor Underserved* Summer;1(1):181-4. Available from: PubMed; PMID 2134842

Washington State 2007. RVU Cookbook. 2006. http://www.chs.hca.wa.gov/doc/Rvu-ckbk.pdf. Accessed March 4, 2007.

Watson MR, Horowitz AM, Garcia I, Canto MT. 1999. Caries conditions among 2-5-year-old immigrant Latino children related to parents' oral health knowledge, opinions and practices. *Community Dent Oral Epidemiol* 27(1):8-15.

Watson MR, Manski RJ, Macek MD. 2001. The impact of income on children's and adolescents' preventive dental visits. *J Am Dent Assoc*. 132:1580-1587.

Weintraub JA, Burt BA. 1987. Prevention of dental caries by the use of pit-and-fissure sealants. *J Pub Health Policy*. 8(4):542-560.

Werner CW, Gragg PP, Geurink. 2000. The facilitating role of mobile dental van programs in promoting professional dental education. *Braz Dent J*. 11(2):127-133.

Werner CW, Pereira A, Eklund SA. 2000. Cost-effectiveness study of a school-based sealant program. *Journal of Dentistry for Children*. 93-97

Werner CW, Pereira AC, Eklund SA. 2000. Cost-effectiveness study of a school-based sealant program. *ASDC J Dent Child* 67(2):93-7, 82. Available from: PubMed; PMID 10826042

Whiteside DF. 1990. Comment in: *J Health Care Poor Underserved* 1(1):181-4. Available from: PubMed; PMID 2134842

Wilde J. Identification of multiple equation probit models with endogenous dummy regressors. *Economic Letters*. 2000;69:309-312.

Wooldridge JM. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

World Health Organisation. 2003. *Oral Health Promotion: An Essential element of health-promoting school*. WHO Information Series on School Health #11. Geneva, Switzerland:WHO Document Production Services. 2003:10. Available at http://www.who.int/oral_health/publications/report03/en/. Accessed April 6, 2007.

World Health Organization. 1946. Preamble to the Constitution Adopted by the International Health Conference , New York, June 19-22, 1946

Yu SM, Bellamy HA, Schwalberg RH, Drum MA. 2001. Factors associated with use of preventive dental and health services among US adolescents. *J Adolescent Health*. 29:395-405.

Vita

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Anjum was selected through a nationally-competitive examination for the elite district management service in Pakistan. He worked at various executive positions in the government for over eight years. He was the General Manager of the Punjab Information Technology Board before his return to the United States for his doctoral studies. He has also worked as a Medical Research Specialist and Vice President for Information Technology at the Medical Institute for Sexual Health in Austin.

Anjum has presented his work in national and international conferences on a variety of policy-related topics including information technology policy, telemedicine, health economics, civil service reforms, and public health.

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